REPUBLIC OF MOLDOVA

MINISTRY OF ECOLOGY, CONSTRUCTION AND TERRITORIAL DEVELOPMENT

TECHNOLOGY NEEDS ASSESSMENT AND DEVELOPMENT PRIORITIES

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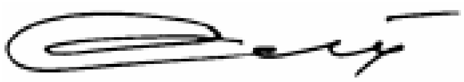
FOREWORD

The process of clime change, in line with other phenomena taking place at the global level, is considered by United Nations Organization as one of the most difficult problems that the mankind will face in the XXI-st century. This phenomenon is determined by the essential changes that are taking place in the atmosphere, which in the last decades of the XX-th century reached a dangerous level for a smooth evolution of life on the Earth. Currently it is considered that one of the main factors that intensify the respective phenomenon are the anthropogenic emission of GHGs. In order to stop this phenomenon, the international community worked out and approved the UN Framework Convention on Climate Change – a document fated to, at first stage stabilize, and later on – diminish the amount of anthropogenic emissions on the global scale. The Republic of Moldova adhered to this convention on June 9, 1995. One of the immediate achievements of our state after the adherence to this Convention was the development of the First National Communication, a report which had a main objective to inventory the GHG emissions and draft a plant of actions with regard to alleviating the impact of the climate change on various components of the environment and on social-economic activities. The next step undertaken by the Republic of Moldova in the framework of the above mentioned convention is to identify the possibilities of rehabilitation of most important economic sectors, as well as technological, economic and environmental possibilities to implement renewable energy sources, with the purpose to reduce the GHG emissions. In the Republic of Moldova the share of the economic sector calculated for the last decade, accounts to 55-80% of the annual GHG emissions. Due to these reasons it is considered that it is the energy sector that needs, first of all, to be the domain where the action plan should be implemented.

The present study is devoted to identifying possibilities of abating GHG emissions, through the intermediary of the energy sector rehabilitation and implementing renewable energy sources. We hope that the present work will be useful for the policy makers in taking their decisions concerning socio-economic development strategies of the country and energy sector, for the specialists from the energy sector and environment protection, for businessmen, investors, and for the non-governmental sector, simultaneously contributing to consolidating the institutional and social framework which would favor the participation of the Republic of Moldova, together with other countries, in resolving this global problem – climate change.



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THE ENERGY SECTOR

The current situation

The energy sector is an integral part of the national economy, which deals with the production, administration, transportation and distribution of the electric and thermal energy for the living, public, and industrial sectors, and consists of: the electro-energetic, thermo-energetic and gas, solid and liquid fuel supply sectors. The energy sector has a crucial role in the economy and consumes yearly cca 40-60% of the total quantity of fuel used in the country.

The energy sector of the Republic of Moldova was created in the period 1950-1980 in the conditions of the centralized economy. From the technical point of view, in this period the sector evolved in the sense of the integrated power increase of the installations and industrial units of energy production, and the practice of low prices for the fuel consumed and the energy produced, maintaining this situation artificially through huge Governmental subsidies and grants. The main feature of the energy sector created in that period was a high degree of centralization.

During the 1990-2000 period in the Republic of Moldova there was registered a deep depreciation of all economical and social indices. An extremely complicated situation occurred in the respective period in the national energy sector as well, characterized by the following significant factors: an advanced moral and physical wear-out of the installations and equipment, a low quality of the performed services and the energetic efficiency diminution, a high energetic intensity, 3-4 times higher than the respective indices in the industrially developed countries, the dependence on the import of the primary energetic resources (cca 98%), a limited number of fuel and electricity providers, the low level of electric energy generating capacities for the coverage of the consumption necessities (only cca 30% on the right bank of the Nistru river), the low capacity of the electric connection lines on the West direction (only 3 lines of 110kV), the unfavorable structure of the electric transport network from the point of view of the state energetic security, the tendency of continuous mutual debts increase, the financial blocking of the energetic enterprises caused by huge debit and credit debts, the double increase of energy and fuel losses during the last years, the lack of investments for the energy sector rehabilitation and development.

The technico-economical characteristics

In the conditions of a high dependence on the import of the primary energetic resources, the energy and fuel supply in our country in the period 1990-2000 was marked by serious deficiencies, caused by the application of tariffs that didn't reflect he real costs, by the allocation of some rebates and compensations without financial coverage, as well as by the implication of the decisive factors in the relations between the suppliers and the consumers. This situation lead to financial blocking and to an unprecedented energy crisis.

So, because of the lack of financing for an ample import of energetic resources, the total fuel consumption in the period 1990-2000 generally reduced in the national economy more than seven times, while the rate of electric and thermal energy production decreased more than four and, respectively, seven times. During the years of transition the economy of the country is in a constant recession, aggravated by the lack of proper energetic resources. As a result, the total import of these reaches 98%, requiring up to 40% from the Gross Domestic Product. In the conditions of rapid increase of prices for fuel and energy, in the period 1990-2000 there were accumulated huge debts towards the energetic resources suppliers.

With small exceptions, all the sources of electric and thermal energy production in the country have the age of cca 20-45 years. The total installed capacity of the power plants from the country constitutes 2950 MW, while the available capacity is only 1300 MW. In 1990 only about 2% of the electric energy were produced at the hydroelectric power stations with the installed capacity of 64 MW, the rest 98% - at the thermo-electric power plants with the installed capacity of about 2950 MW (84% of this potential constituted the installed capacity at the Moldovan Thermo-Electrical Power Plant (MTPP) from the town of Dnestrovsk, situated on the left bank of the Nistru river). For the coverage of the electricity demand, starting with the year 1995, the deficit of installed capacity at the right bank of the Nistru river is covered by the electric energy delivered from the MTPP and by the import of energy from the Ukraine, Romania and, more recently, from Russia.

The technological process at the electric and thermal energy production units (Combined Heat Power Plants - CHPs) from the country is based on the classic steam turbine cycle. Considering the specific fuel consumption at the electric and thermal energy production, the technologies used at the domestic CHPs are not as efficient as those of the analogous installations in the world *(in comparison with the up-to-date installations, the nominal efficiency of the CHPs from the country is two times lower).*

The thermal power sector of the Republic of Moldova is represented by: large centralized heating systems; local centralized and autonomous heating systems. In the last ten years there was registered a continuous tendency of decentralization of large heating supply systems. The condition required for the survival of large centralized heating supply systems is that these should produce thermal and electric energy at a price competitive with the alternative options *(for instance, the massive import of cheap electric energy).* The analysis of the presented information permits to formulate the following conclusions:

1. Despite of the fact that, at present, the CHPs have an old-fashioned technological process, the obsolete machinery, and as a result of this fact work in inefficient regimes – the cost of produced thermal energy at the large centralized heating systems is much lower than that at the enterprises belonging to local centralized and autonomous heating systems.
2. The application of high prices for the energy produced by CHPs and thermal plants (TPs) from the large centralized and local heating systems often has no technical argumentation, is subjective and can be explained, especially, by the bad administration of the respective economical units. This lead to a low level of collecting the payments, situation explained by the population's insolvency and by the low level of payments on the bills for the rendered services;
3. Taking into consideration all the fixed costs of the local centralized heating systems, including the costs of the boilers and of the transportation and distribution networks, the final cost of heating is higher in comparison with the autonomous heating systems. The cost level of the thermal carrier in the local centralized heating systems may be estimated to 290-350 MDL_{2001}/Gcal, while the cost of heating for the autonomous boilers working on natural gas may be estimated to approximately 250 MDL_{2001}/Gcal.
4. Use of the autonomous thermal power plants (individual boilers for buildings or apartments) is considered feasible, especially in the regions with low heating consumption. At the same time, these can be used by the consumers who can afford, from financial point of view, to be independent from the centralized heating systems. Decentralized heating, based on autonomous individual boilers on natural gas consumption, represents a option of equilibrium between the payment capacity and the thermal comfort in the apartments, and an individual option for each consumer.

Directions and particularities of the energy sector development

In the industrialized countries, until recently, the organization of the energetic sector was based on the so-called vertically-integrated structures *(either state or private companies)*, which included all or almost all the segments of the energetic cycle – starting with the production of the primary energetic resources till the delivery of the *electric and thermal* energy to the consumers.

However, in the 80s-90s of the XX-th century, the EU states and other developed countries (the USA, Canada, Japan, Russian Federation etc.) have recognized that the old organization of the complex became inefficient and cannot assure a continuous economical increase any more. Under this situation, tens of states started a deep reformation of the energetic sector orientated to the liberalization of the energetic market. These radical transformations is in full progress on the American continent and in the West Europe, extending rapidly to the Central and East Europe.

Another global trend, specific to the electricity sector especially is the promotion of the distributed generation concept. In some extents is a return to the times of Thomas Edison and Dolivo-Dobro-volski, when there were built small-capacity power plants only for local consumers of energy supply. Starting with the 1970s, it turned out to be more and more difficult to find a location for the large capacity nuclear-electric and CHPs (1000-5000 MW), too expensive and hard to build. Meanwhile, due to the technico-scientific progress, the medium sized power plants (up to 300 MW) are becoming more efficient and can be built in modules in short periods of time.

The distributed generation becomes more and more advantageous from the point of view of cost, efficiency and the impact of the environment. However, in the industrialized countries, presently there is a centralized delivery of electric energy, whose efficiency and technical-economical advantageous are well known.

Other situation is in the thermal energy supply sector. Although the thermal networks appeared in some EU countries at the end of the XIX-th century, until the energy crisis in 1973 the thermal energy supply in the urban localities was made mainly on the basis of the autonomous heating systems. The situation changed in great extent after the energy crisis in 1973. The main factor that convinced the consumer to change the usual mode of heating, promoting the development and the optimal combination of the centralized and decentralized heating systems, was the considerable increase of the prices for oil products and other high-quality types of fuel used in the autonomous heating systems.

The energy crisis, and later the ecological problems, raised to the governments from the developed countries the problem of energy security, energy conservation and the reduction of the energy sector impact on the environment. Starting with the 1970s, a series of countries there were taken legislative, economic and financial measures with the purpose to encourage the development of the centralized heating supply systems on the basis of two principles, that permit to reduce considerably the GHG emissions: (I) cogeneration and (II) the utilization of the renewable energy sources.

I. The process of cogeneration means the combined production of the electric and thermal energy. The global output of the energy production for the co generating power plants varies between 85-92% in comparison with the maximal output of about 55% for the power plants producing only electric energy. In comparison with the separate production of the electric and thermal energy, the anticipated economy of energy is up to 40%.

II. The utilization of the renewable energy sources in the industrialized countries' heating supply system is widely practiced. It is preferred the utilization of the biomass energy, solar energy, geothermal energy and of the low-potential heating sources, on the basis of the heat pumps.

The current situation in the energy sector of the Republic of Moldova is characterized as complicated, either from the economic point of view and that of the energy efficiency and security of supply. Although in the last years the Government has made definite steps for the sector's reformation of the energy sector, adopting a series of resolutions regarding the demonopolization, decentralization, the encouragement of competition, the attraction of private investments, the crisis of the energetic sector keeps on worsening. The solving of this problem is possible only by carrying on the economic reformation of this sector.

Although there does exists the legislative framework necessary for the reforms promotion, the transition to the market economy in this sector goes hardly because of the insufficient training of the managers and of the staff for the activity in the new historical conditions.

The energy sector is deeply affected by the disparity between the demand and offer, by the insufficiency of the internal and external investments and by the ruined potential of production. The mission of the state in such a situation is to create and guarantee the necessary conditions for an efficient activity of the energetic sector. So, the main objectives of the national energetic policy are the following:

– The promotion of an active policy of energy conservation to the consumer.
– The increase of the generated efficiency and the electricity production capacity through the implementation of efficient technologies with a minimal impact on the environment.
– The involvement of the native energy resources, including the renewable ones in the balance of consumption, in the cases these turn out to be economically competitive.
– The guarantee of the state energetic security, inclusively by the diversification of the types

of fuel used on the territory of the country, of the sources and import means of the energy resources.

– The environment protection, inclusively through the respecting of the European norms and standards of the environment pollution.

The assessment of the GHG emissions proceeded from the energy sector

The energy sector is the cause of many environmental problems. It is well known the existence of a tight correlation between the process of energy production, and the polluting effect on the environment. In the process of energy production from the organic fuel with a high content of carbon (55-95%) – natural gas, residual fuel oil, coal – in the environment there are emitted considerable quantities of polluting gases and solid particles. The anthropogenic emissions of greenhouse gases (GHG) have a direct impact on phenomena like climate changes and acid rains.

From the direct greenhouse gases (CO_2, CH_4, N_2O, CFC, PFC, HFC, CF_4, SF_6 etc.), the carbon dioxide is the gas with the most prominent effect. The CO_2 layer in the atmosphere has the role of a unidirectional filter for the solar rays or those reflected or irradiated from the surface of the planet. The increase of CO_2 percent in the atmosphere disturbs the thermal balance of the Terra: the carbon dioxide concentration increased with cca 25% towards the pre-industrial period – from 275 ppmv (parts per million of volume), to 360 ppmv at present. The modifications of only tens of degrees in the global average temperature at the soil surface are sufficient for unpredictable climate changes, and from the year 1856 till present this index grew with 0.5^0C. There already may be observed some modifications of the meteorological conditions, which prove the global change of climate: the intense glacier melting, unparalleled floods, tornadoes, cyclones, draughts and a high frequency of extreme temperatures.

On their turn, the indirect GHG emissions (NO_x, CO, NMVOC, and SO_2), especially the nitrogen oxides and the sulfur dioxide, generate acid rains, with a considerable impact on the people's health, forest ecosystems and agrophytocoenosis *(according to the recent assessments, the losses caused by the acid rains are estimated to cca 6,000 Euro per one tone of SO_2 or NO_x emissions).*

The inventory of the direct and indirect GHG emissions resulted from the fossil fuel combustion at the electric and thermal energy production was accomplished for the period 1990-2000 on the basis of the guidelines elaborated by the Intergovernmental Panel for Climate Changes (IPCC, 1996).

The GHG emissions were estimated on the basis of the primary data on fuel consumption, presented by the Department of Statistic and Sociology, as well as in accordance to the data presented by the Ministry of Energy, the Ministry of Education, the Ministry of Health, "Termocom" JSC, the "Termocomservice" JSC and by the local public authorities from the counties. The assessment of the emissions derived from the fossil fuel combustion in the energy production at the thermal plants from the localities on the left bank of the Nistru river for the period 1990-2000 wasn't accomplished because of the lack of data.

As the calculation instrument there was used the ENPEP *(ENergy and Power Evaluation Program)*, elaborated by the Argonne National Laboratory (USA) and the International Agency for Atomic Energy (IAAE).

The principal GHG emissions generating sources from the Republic of Moldova are the MTPP, 3 municipal CHPs, 9 CHPs belonging to the sugar factories (SF) and approximately 3,921 thermal plants of different capacities. In the period 1990-2000, the direct GHG emissions reduced almost 5 times *(from 13,483.2 Gg in 1990 to 2,779.4 Gg in 2000).* This reduction was caused by the general diminution of fuel consumption and the increase of the share of the natural gas in the structure of the fuel consumed in the sector of electric and thermal energy production, especially at the MTPP.

In 1990 the MTPP had the biggest share in the structure of the total GHG emissions, approximately 74% from the total. Subsequently, especially after the year 1995, the share of the MTPP in the structure of the total GHG emissions decreases considerably, to 51%. Unlike it, the share of the CHPs and of the TPs increases, constituting in the year 2000 38% and, respectively, 11%.

In the period under consideration (1990-2000), the indirect GHG emissions generated by the energy sector reduced considerably: the NO_x emissions decreased 5.2 times, the CO emissions – 3.7 times, the NMVOC emissions – 3.9 times and the SO_2 emissions –34 times. This situation is explained both by the diminution of the general fuel consumption and by the process of replacing the polluting types of fuel – the residual fuel oil and coal, with others, less polluting – the natural gases.

In the period under consideration there also changed considerably the fuel consumption at the energy sources in the structure of the total direct and indirect GHG emissions: the share of the coal and residual fuel oil decreases, while that of the natural gases grows.

THE TRANSPORT SECTOR

General features

The transport sector in the Republic of Moldova has the following structure: the road transportation, the railway transportation, the air transportation, and the naval transportation. The share of the types of transport is disproportional: over 86% - the road transportation, 12% - the railway transportation, and only 2% - the other types of transport – the air and naval transportation.

The road transportation. In the period 1990-1994 the number of the road transport units in the country was constantly decreasing, and reduced in this period with cca 56,000 units *(from 319.6 thousands in the year 1990 to 263.6 thousands in 1994).* Subsequently, the situation changes considerably. So, after the year 1995 the number of the road transport units (*including the passenger vehicles (motorcars) and the autobuses)* was constantly increasing, so that in the year 2000 the car park was of cca 322.7 thousands. However, in general, the total number of the transport units in the Republic of Moldova in the period 1990-2000 reduced with approximately 80,000 units (from 520.3 thousands in 1990 to 440.6 thousands in 2000). This situation is explained by a drastic reduction in that period of the number of motorcycle transport units *(from 200.6 thousands in the year 1990 to 91.4 thousands in 2000)*, of trucks *(from 77.2 thousands to, respectively, 61.7 thousands)* and of special road transport units and non-road mobile sources and machinery *(from 17.6 thousands to, respectively, 5.7 thousands)*.

Considering the fact that in the period 1995-2000 the vehicles park in the Republic of Moldova was constantly increasing, there might have been prognosticated the increase of the principal types of fuel consumption as well. But this increase is not reflected in the official statistical sources, moreover, according to these, the gasoline consumption, for instance, decreased from 662.6 kt in 1990 to 121.6 kt; the Diesel oil consumption – from 1005.6 kt, respectively, to 200.3 kt; the liquefied petroleum gas (LPG) consumption – from 14.0 kt, respectively, to 1.5 kt, while the liquefied natural gas consumption (LNG) – from 13.1 kt, respectively, to 9.2 kt. It is considered that the data presented in the official sources regarding the fuel consumption in the road transport sector do not reflect the real situation because of the imperfect methods of accounting the fuel import and as a result of the shirk from the accounting *(according to the assessments made by the specialists from the Ministry of Transport and Communication in the period 1994-2000 in the country there were illicitly imported about 800-1400 thousand tons of fuel yearly).*

The railway transportation. In the period of transition to the market economy the railway sector was seriously affected by financial problems. Because of the lack of the necessary money for the maintenance and reparation of the rolling stock, in the period 1990-2000 there reduced considerably the number of the railway transport units: the number of the railway engines – 4 times *(from 324 units in 1990 to 76 units in 2000)*, and that of the Diesel trains – twice *(from 44 units, respectively, to 22 units).*

At the same time, in the period 1990-2000 the fuel consumption at the Moldovan Railways decreased cca 5.7 times, mainly as a result of a drastic diminution of the cargo and passenger transport caused by the precarious economical situation.

The naval and air transport. The share of the naval and air transport in the Republic of Moldova was and still is insignificant. The precarious situation of the national economy, characteristic of the period 1990-2000, had a considerable impact on these types of transport as well. So, in the year 2000, the fuel consumption in the internal naval and air transport decreased cca 1.7 times *(from 77 tons in the year 1990 to 46 tons in the year 2000)* and, respectively, 4 times *(from 68.1 kt in the year 1990 to 17.1 kt in the year 2000)* in comparison to the year 1990.

Directions and prospects in the transport sector development.

The Ministry of Transport and Road Administration elaborated in the year 1997 the concept for the transport sector development in the period until the year 2010. According to it, the strategy of the transport sector development is supposed to be orientated to the liberalization of the wares traffic, the renewal of the existent rolling stock, and the further development of the transport, including the railway transport, the electric transport, the river and maritime transport.

The assessment of the GHG emissions proceeded from the transport sector

The assessment of the direct and indirect greenhouse gases emissions proceeded from the fuel combustion in the transport sector in the period 1990-2000 was accomplished on the basis of the guidelines elaborated by the Intergovernmental Panel for Climate Changes (IPCC, 1996). The GHG emissions proceeded from the transport sector were estimated on the basis of the primary data on fuel consumption, presented by the Department for Statistical and Sociology, the Moldovan-Russian open company "Moldova-Gaz", the Ministry of Agriculture and Food Industry of the Republic of Moldova, The Road Police Direction, the General Staff of the National Army an the State Administration for Civil Protection of the Republic of Moldova. The assessment of the emissions proceeded from fuel combustion at the transport units from the localities on the left bank of the Nistru River, for the period 1990-2000, was not accomplished because of lack of data.

The total direct GHG emissions evaluated through the Global Warming Potential for 100 years, expressed in CO_2 equivalent, proceeded from the transport sector, were estimated in the years 1990, 1995 and 2000 to 5,555.6 Gg, 2,110.6 Gg and, respectively, 1,110.4 Gg. In the period 1990-2000 the total direct GHG emissions proceeded from the transport sector diminished with cca 80% towards the 1990 level, for this period being characteristic a tendency of a continuous reduction of these emissions. The direct GHG emissions, expressed in CO_2 equivalent and resulted from the utilization of all types of fuel in the transport sector in the period 1990-2000 proceeded mainly from the combustion of gasoline, Diesel oil and aviation gasoline.

In the period 1990-2000, the share of the road transport in the total direct GHG emissions expressed in CO_2 equivalent varied between 87.7-87.9%, that of the railway transport – between 8.3-7.3%, that of the air transport – between 3.9-4.3%, and that of the naval transport, respectively, between 0.004-0.013%.

In the period 1990-2000, the indirect GHG emissions proceeded from the fuel combustion in the transport sector reduced considerably: the NO_x emissions decreased 5.5 times, and those of CO and NMVOC – 5.4 times. This situation was provoked by the economical recession and, implicitly, by the reduction of the general fuel consumption in this sector.

RENEWABLE ENERGY SOURCES

The wind energy. The Republic of Moldova has such a geographical situation that only few regions from the territory of the country benefit by winds favorable for the development of the wind energy sources. Before the utilization in mass of the steam and internal combustion engines the wind installations for the generation of mechanic energy – the windmills – were widespread on the territory of the actual Republic of Moldova *(for instance, in the year 1901 there were registered 6,208 windmills distributed in the counties in the following way: Balti – 299; Chisinau – 980; Tighina – 907; Soroca - 371; Orhei – 626 etc.)*. The majority of the windmills, of pyramidal type, were spread in chain on the hillocks and on the hilltops, and many of them worked in the inter-war period as well.

During the years '50s of the past century, in the republic there were more than 350 mechanical wind installations, destined exclusively for pumping in the water-supply systems, and for fodder preparation in the collective agricultural farms. Those were air engines with many blades with the nominal output of 6.2 horsepower or cca 4.6 kW at the estimated wind speed of 8 m/s. They ran with enough efficiently, being replaced gradually in the period of 1960-1964 by more convenient and cheaper in the exploitation electrical systems. In the long run, the entire rural electrification, that took place in that period, and the very low prices for electricity excluded the wind energy sources from competition. At present in the Republic of Moldova there are running only a few experimental wind installations of light output, used for the production of electricity in the autonomous conditions. In the last decades, along with the ten times increase of prices for energetic resources, the interest in the renewable energy sources (RES), increased considerably and its use can increased in proportions in the forthcoming future.

The implementation potential. At the actual level of development, the "commercial" wind energy conversion's technologies, the locations that assure an average yearly speed at the wind turbine axe's altitude of 7 m/s and more with the specific wind energy higher than 350 W/m^2 are considered favorable. On these criteria it may be concluded that the Republic of Moldova has quite extended zones with a favorable for energetic exploitation wind potential, of which the most important are: the Tigheci heights; the Nistru region's heights; the Ciuluc hills; the central tableland of Moldova; a great part of the hill's territory of the Cahul and Taraclia counties. After performed evaluations, perspective locations have been also emphasized in the considered favorable zones: that is some predominant hills in the proximity of accumulation lakes (Dubasari, Ghidighici, Ialoveni, and others).

Considering the following circumstances – the specific nature of the electrical load distribution on the country's territory, the limited area of locations with favorable meteorological conditions and of the grounds that may be withdrawn of the agricultural circuit, and also the small financial possibilities of the population – it is considered that the wind power plant with an installed capacity of 10–15 MW will have a larger spreading in the Republic of Moldova. After a minute examination of about 50 scenarios of equipping some eventual wind power plants with made by European firms air–generators, it was concluded that, in the Republic of Moldova's conditions, the most efficient are the air – generators with a installed capacity of 0,6 – 1,5 MW, the specific nominal energy of 350 – 600 W/m^2 and the tower's height of 70 – 95 m. These aggregates also foresee the rotation regulation depending on the wind speed and, respectively, on the use of the available output in the low wind speed areas. In this way, it may be observed that the price for the energy produced at this power station is of about 5 cents/kWh, a favorable economical price even at the current prices of delivering electricity to the consumers. Where placement conditions are most favorable the price of the produced by the power stations energy will be of 4 – 4,5 cents/kWh.

The solar energy. The first investigations concerning the solar energy use in the Republic of Moldova were initiated at the end of the 50-s of the past century by the co–workers of the Institute of Energy of the Academy of Sciences of the former SSRM. In that period there were elaborated, assembled and tested the first thermal solar installations: a solar hot house with the heat accumulation in the ground, two solar installations for water heating assembled at the children camps from the villages Vadul-lui-Voda and Condrita. Afterwards, as a result of the extremely low prices for the used fuels and of the lack of a consequent policy of renewable energy sources promotion, the implementing of these installations had been given up. The works of implementing the solar installations was resumed in the 80s of the XX-th century, along with the serial production of the solar collectors at some factories of the ex-USSR. In the period of 1982–1987, at the domestic specialized institutes "Ruralproiect", "Urbanproiect", "Agropromproiect" solar installations for water heating were designed at the following objectives: a four room's house in the village of Bucuria, district Cahul; 90 places' kinder gardens in the villages of Harbovet and Berezchi, district Anenii-Noi; a 240 places' hostel in the village Novoselovka, district Orhei; a 160 places' kinder garden in the village of Malaiesti, district Criuleni; a solar tobacco drying stove in the district Briceni, etc. Most of the sun installations were destined to water heating in the March–October period. The entire area of the sun sunlight baterries was of about 12 thousand m^2, which allowed the substitution of about 1,000 t.c.e.

Most of these installations do not run because of the bad quality of the sunlight collectors, of the corrosion and of the maintenance works' suspending. Starting with 1993, solar installations for water heating are produced in the Republic of Moldova at the enterprise "Incomas" JSC. We mention that, so far, there were implemented 140 installations with solar collectors, with an area of 1.4 and 2.2 m^2. The entire area of the assembled installations is of about 300 m^2. In the same time in the country there were tried some experimental photovoltaic (PV) installations for water pumping and for communication systems and weather stations. Because the whole population of Moldova has access to the public electrical networks, the PV solar energy may have a relatively limited segment of use: the light irrigation and the rural consumers of electricity with light output, territorially scattered (for example, the anti-hail protection stations, the forest folds, etc.).

The implementation potential. In the Republic of Moldova, the theoretical duration of sun shine is of about 4,445–4,452 hours a year. The real duration makes up 47–52% or 2,100–2,300 hours. A considerable part of the sun shine hours are in the months of April–September and makes up 1,500–1,650 hours. The global radiation in conditions of middle nebulosity makes up 1,280 kWh/m^2 per year in the North area and 1,370 kWh/m^2 per year in the South. For the priority technologies (*water heating installations; fruit, vegetables and medicinal plants drying installations and photovoltaic - PV installations)* the available potential of energy has been determined, taking into consideration the exploitation period of the installations, the solar radiation particularities and the inclination angle of the collector or of the PV modulus. For this purpose, it was used the method described by J. Duffie and W. Beckman. The data concerning the solar radiation on a horizontal area in conditions of middle nebulosity and clear sky had been taken from the State Hydrometeorology Service publications. For the water heating, agro-food drying and pumping installations were determined the average monthly amounts of used solar energy in the respective periods of running. The optimal inclination angle of the collectors, or of the PV modulus, also had been calculated. As optimizing criteria, the maximal amounts of the solar radiation in the top months of the exploitation period, when the solar radiation on a horizontal area is lowering, had been chosen. For the PV pumping installations, the fact hat they run effectively only in the sun shinning hours had been taken into consideration.

So, the efficient period of exploitation of the water heating installations makes up about 7 months (March–October period), with the optimal inclination angle 40^0, the global sun radiation increases in March with 21%, in October – respectively with 50%, and in July it lowers with 10% in comparison with the horizontal plan of the collector. The exploitation period of the installations *for fruit, vegetable and medicinal plants drying* coincides with the maximal sun radiation period, extending usually on the period of May–October, with the with the optimal inclination angle of the solar pick-up of 35^0. In comparison with the horizontal plane of the installation, for this angle, in September the global radiation will be 20% higher, and in October – 46%. Unlike the thermal sun installations, the pumping installations without electricity accumulators ran only in conditions of clear sky, in other words, as long as direct radiation exists (in the period April-October there is direct radiation with the PV installations' inclination angle 25^0).

Biomass energy. The notion of the biomass signifies both the biomass proceeded from the process of the agricultural plants' growing and from the forestry, and that in the shape of organic residues and wastes. The biomass energy proceeded from the forestry is used, in most of the cases, by its direct combustion in the stoves that exist mostly in the houses of the rural environment. In this case, the obtained thermal energy is used for houses heating during the winter and for domestic purposes, regardless of the period of the year. The implementing of the advanced technology of the biomass energy conversion, proceeding from the agricultural and forest wastes, into thermal and/or electricity, is limited by a number of factors, like: the high prices of these technologies; the limited quantity of such resources and the great territorial dispersion.

The implementation potential. The main generators of used in energetic purposes biomass in the Republic of Moldova are the forestry, the agriculture, the livestock sector, the food industry and the communal farmstead of the locative sector.

For example, the State Forestry Agency "Moldsilva" yearly delivers to the national economy 250-350 thousands m^3 of fire wood, so as 60-70% of the rural population buys and use as fuel for heating the houses.

Another important source of renewable energy in the Republic of Moldova is made up by the agricultural provenience biomass, obtained from the pruning of the orchards and vineyards, and also the one obtained as vegetable residues in the agricultural sector: wheat straw, maize stalks and cobs, sun flower and tobacco stalks and others. In accordance with the estimations of the specialists from the Ministry of Agriculture and Processing Industry, from the State Agraricultural University, the Technical University of Moldova, the Institute of Energy of the Academy of Science of Moldova and the Department of Statistical and Sociology, the energy potential of the biomass is impressive and varies between 650-900 thousands t.c.e. yearly, but it is to be capitalized more efficiently.

Other great biomass generators are the livestock sector, the food industry and the communal economy of the housing sector. Of the organic residues proceeded from these sources (*the animal manure and dejections from the livestock farms; organic refuses from the food industry and the leather processing industry; the municipal solid wastes; the mud accumulated in the communal and industrial purging stations; the residual waters with an increased containing of organic pollutants, etc.)* appreciable quantities of biogas, recoverable through the anaerobic bioconversion processes, may be obtained.

The biomass generating potential in these sectors depends first of all of the economical factors. So, for example, the generating potential of the animal manure in the livestock sector is determined by the animals and birds effective, by the animals and birds rate quality and, respectively, by their productivity, being estimated to cca 67.1 million m^3 of biogas per year. In accordance with these calculations, and also from the effective of the great stock-breeding complexes, it was estimated that the appropriated number of middle and large capacity fermenters (a reasonable volume between 100 and 800 m^2) utilizable mostly in the agricultural collective farms, is of about 90.

Nowadays 38 mechanical-biological treatment plants run in the Republic. As a consequence of the economical crisis and of the water consume countering; these plants' capacity was almost twice reduced. But the sludge quantities proceeded from the treatment of the communal waste waters, that now have an increased pollution rate with materials in suspension, may be considered diminuend only with 1/3 in comparison with 1995, when these formed cca 267 t of dry substance (d.s.) per day. At the specific debit of biogas of 0,33 m^3/kg d.s., it is possible to obtain about 60 thousand m^3 of biogas per year. For the efficient use of these capacities about 40-60 methane-tankers with a reasonable volume of the fermenters between 250-1,500 m^3 could be used.

From the category of industrial waste waters make part, mainly, the waters proceeded from the food industry enterprises: alcoholic drinks and juice, canned goods, milk, sugar factories, are part of this category of waste waters. Taking into consideration the fact that in 1995 only the anaerobic fermenting of the resulted from the mechanical-biologic treatment of the waste waters was possible at the treatment stations of the sugar scrubbing stations and canned goods factories of the country, the estimated biogas quantity was of 121 thousands m^3/day. Considering the economical situation, nowadays the potential of recovering the biogas from the industrial waste waters is of about 14,7 mil. m^3 a year. For its efficient use, 40 methane-tankers with a reasonable volume of 500-1,000 m^3 each would be necessary.

In accordance with the statistical data, during 1998 about 1,300 m^3 thousands of waste, including 700 thousands m^3 proceeded from the urban area, were collected aggregately and stored in special landfills. The volume of the accumulated at the existent landfills Municipal Solid Waste (MSW), in accordance with the estimations effectuated by the ecology inspectors, is of about 30 mil. m^3. Because most of the waste landfills do not have authorization, being exploited with deviations from the technological demands, they can not be used for the methane recuperation. In the meantime, there are waste landfills in the republic that are being exploited for many years and the possibility of the methane recovering would be useful. The accumulated in the city of Chisinau wastes are evacuated to the Ţânţăreni's landfill, that had been exploited from 1991 till 2000, about 8 mil. m^3 being stocked here. In its turn the landfill from the municipality of Bălţi has been exploited for about 30 years. Nowadays, the launching of a separate collecting and/or sorting the municipal solid wastes to the source program is necessary in the Republic of Moldova in the purpose of organizing a centralized stocking and their recirculation. Later, in conditions of an optimal exploitation of the existent and new-made landfills, it will be possible to recover yearly about 3 mil. m^3 biogas per year.

Another channel of transforming the MSW in biogas is the "The Valorga Process" that consists of their anaerobic fermenting in wet state. After the example of the installation of Tilburg (Holland) and Amiens (France), cca 700 thousands tons of MSW that are yearly accumulated in the urban area can be treated. In this process, the average specific production of biogas is of 99 Nm^3/t MSW that result in maximum 69 mil. m^3 biogas per year. Of 1 m^3 of the fermenters it can yearly be obtained about 600 m^3 of biogas that leads to a demand of fermenting reasonable capacity of 115 thousands m^3. For the reasonable volume of 1,500,000 m^3 fermenter about 80 methane-tankers will be necessary.

The best majority of the installations for the anaerobic biomass processing are rather expensive. The construction of these installations in the industrially developed countries is, as a rule, subsidized by the state in a volume of 20-40%. The energy produced by 1 m^3 of biogas in the respective countries costs cca 0.3 USD, and when the gas is converted into heat and electricity its cost grows to 0.4 USD. At present, only five plants for anaerobic treatment of the industrial waters (Chisinau, Tiraspol, Balti, Tighina and Cupcini) are endowed with installations for sludge and mud anaerobic processing and biogas recuperation (methane-tanks). The rest of the stations are endowed with open fermenters, without collecting the emitted biogas. None of those five treatment plants endowed with methane-tanks uses these fermenters, and as a result the biogas is emitted in the atmosphere from the surface of drying platforms where there is deposited the unfermented mud.

TECHNOLOGY NEEDS ASSESSMENT. THE ABATEMENT OF THE GHG EMISSIONS IN THE ENERGY SECTOR

The electrical power sector

In all the countries of the world, the power system makes up ones of the most important sources of GHG emission. Among the possible ways of these emissions' abatement, the rehabilitation of the utilizing fossil fuels installations is one of the most efficient steps.

The rehabilitation of the power system has two components: the rehabilitation of the existing installations, *(inclusively through the span of life-time prolongation, increase of the unitary capacity, passing from a fuel with increased carbon content to one with a decreased content, for example:* from coal to natural gases*, efficiency increasing, the replacement of the types of fuel with high carbon content by the fuel with lower carbon content, the output increase, the abatement of the GHG emissions)* and the replacement of the plants that are at the end of their normativ life time with new ones, based on up-to-date technologies.

For the identification of the long-term cover of electricity demand possibilities, the Institute of Energy of the Academy of Science of Moldova, with technical assistance from the International Agency for Atomic Energy (IAAE), made an integrated study aimed to identify the optimal variants for the electrical power sector development for the period 2000-2030. The discounted evaluations were made with the help of the computerized calculus models package ENPEP (ENergy and Power Evaluation Program), elaborated by the National Laboratory Argonne (USA) and IAAE. The forecast of the long-term electricity demand (2000-2025) was done with the help of the MAED model (Model for Analysis of the Energy Demand) of this package and the appreciation of the optimal variant – with the help of the WASP model (Wien Automatic System Planning).

In this study, to identify *the covering the electricity demand possibilities* for the period 2000-2030 the indexes of social-economic development of the country has been estimated, being analyzed nine possible variants of developing the power system, only three being identified as possible to the practical implementation, being considered as assuring a lasting development of the power system variants. The identified variants were: *Variant 1,* generically named *"Import*", that supposes: the re-powering of some existing plants (without construction of new production capacities); the import through the existing inter-connection lines and through new lines that are to be constructed; *Variant 2,* named "*Auto-balance"* that supposes: the re-powering of some existing plants; the construction of capacities based on gas turbines and groups with combined cycle on natural gases capacities; a decreasing tendency of the electricity import; participating in the finalizing the U2 generation unit from NPP Cernavoda (România) with an installment of 200 MW (after 2008); V*ariant 3*, named "*Development without imposed conditions*", makes up an intermediate option, based on the following principles: the re-powering of some existing plants; the construction of capacities based on gas turbines and groups with combined cycle of different output capacities; the import of electricity in the convenient economic conditions through the existing inter-connection lines and through new ones; participation in the finalization of the U2-NPP Cernavoda generation unit with an installment of 200 MW (after 2008).

After an integral analysis of the possibilities to meet the electricity demand for the period 2000-2030, it was concluded that the Variant 3 ("Development without imposed conditions") means an optimal way of developing the electrical power system of the Republic of Moldova. The main arguments in support of this option are: (I) the respective variant entails the lowest discounted total costs for the entire period of study; (II) it is a balance of electricity import, re-powering of some existing installations and the construction of new capacities (gas turbines of 51 MW and combined cycle groups of 179 MW); (III) it allows fulfill the required conditions for connection of the energy system of the Republic of Moldova to UCTE system by reinforcing the interconnections to West and the internal network on the South-North direction; (IV) it assures a high energy security of the country.

As the Variant 3 *"Development without imposed conditions"* was considered as an optimal model for developing the electrical power system of the country for the analyzed period (2000-2030), the economical, technological and financial features of this variant supposes a favorable, most significant effect for the environment. Out of these considerations, the given variant served as a basis in the evaluations concerning the abatement of the GHG emissions through the rehabilitation of the electrical power facilities, on the basis of this variant (*"Development without imposed conditions")* being elaborated three *scenarios to meet the electricity demand, which include, also, options for the GHG emissions*, namely: the Base Line Scenario – BLS, the Inter-Medium Scenario – IMS, and the High-Alternative Scenario - HAS.

The main options of these scenarios are: (a) the electricity production efficiency has the following amounts – 38, 42 and 52%; (b) the investment costs of the power plant rehabilitation corresponds to the considered efficiencies.

The comparison of the analyzed scenarios allowed the emphasis of the following aspects:

- in comparison with the base line scenario – BLS, the implementation of HAS scenario will lead to a 2,8% reduction of the discounted total costs and will allow, simultaneously, a reduction of the total volume of direct GHG emissions with about 20%;
- in comparison with the BLS scenario, the alternative scenario – HAS and IMS – in the condition of the Republic of Moldova, allow obtaining a reduction of the GHG emissions of 70-80 kg CO_2 equivalent to each USD invested;
- each percentage of increasing of the modified technological equipment rate intermediate the re-equipment contributes to the reduction of the total direct GHG emissions in a volume of 0,84-1,125 mil. tons for the analyzed period.

Taking into consideration all these aspects, the HAS scenario has been considered as the optimal scenario for the development and functioning of the power system of the Republic of Moldova, as it proposes a balanced structure of the own forces and of the electricity import, assuring a high energy security and a maximal abatement of the GHG emissions.

As for the aspects regarding the promotion of the rehabilitation in the electrical power sector, until initiating the privatization of the production and distribution electricity companies in the Republic of Moldova, the responsibility for developing the electricity sources, as well as for assuring the consumers with electricity, was an exclusive prerogative of the state, at present, there is an electricity market in the Republic: three of the five electrical distribution networks (EDN) were privatized by the Spanish company Union Fenosa, and other two are in privatization process. It is also being intended to privatize the electricity production sources; the distribution companies – both the state and the private ones – are licensed to supply electricity at settled rates, negotiate independently the acquisition of the electricity from the power stations and the independent suppliers. So, the assurance with electricity is being effectuated through market mechanisms. Out of the related above, it is concluded that the capitalization of one or other developing the electricity scenarios, can not be effectuated through a simple state intervention, but in accordance with the energy market functioning regulation, that has as a major objective the maximal reduction of the delivered to the beneficiaries electricity. The problem of the GHG emissions abatement is very complicated and must be tackled very attentively, especially in the electrical power sector, where the plants are functioning in system.

The thermal power sector

The main features of the thermal power sector in the Republic of Moldova was and continues to be the high degree of centralization (in different localities of the country this index varies between 0,4-0,85). The main thermal power sources are the district, town, enterprise thermal plants, and in municipals – the power combined heat and power plants (CHPs). Though the centralization is considered a positive factor in supplying with thermal energy, many of the heating systems existing in this country have a non-rational structure (the heat sources are located far from the load center of the consumption, the networks have exaggerate lengths, and for assuring the necessary pressure to the consumers intermediary pumping stations are implemented). Besides, the thermal power sector of the country has a number of other drawbacks, as: the low amount of the combined heat and power plant coefficient, high degree of physical wear-out of the equipment, non-utilization of the local fuels and of the renewable energy sources, etc. To all these difficulties, in the last period, the drastic reduction of the thermal energy demand, the insolvency of a great part of the consumers have added. At present, the main drawbacks of the thermal power sector, which have to be removed without delay, are: the bad quality of the performed by the supplying with heat systems services and the exaggerate tariffs for the delivered thermal energy. The bad quality of the supply with thermal energy service (the non-adequate temperature level of the thermal factor, the frequent disconnections of the hot water supply systems, the belated connection and the before-time disconnection, the lack of an adequate temperature regulation in the heated rooms, etc.) represent the main causes of the solvent consumers giving up the centralized heating systems.

Because of the fossil fuels own resources deficiency, the Republic of Moldova is compelled to import these resources at world prices, and, sometimes, even higher, that, alike with the inefficient utilization of the fuel and below any level management, generates prices that cannot be paid by the great majority of the consumers. For the bettering of this situation, besides a number of steps for the reorganization of the systems by de-monopolizing and privatizing them, legislative steps, having as a purpose the drawing of the investments and the increase of the branch efficiency, the optimization and rationalization of the thermal energy supply systems, and the re-equipment of all the links of the thermal-energy sector. So, we refer to: (I) the thermal energy generating sources; (II) thermal networks; (III) installations for the thermal energy utilization. The rehabilitation will be, along with the main factor that will better the thermal-energy sector impact on the environment, establishing both the noxa and the GHG emissions abatement.

The re-powering of the thermal energy generating sources. Rehabilitation of existing heat sources aims at increasing the efficiency of fuels use or replacing fossil fuel with renewable energy sources (solar, wind, hydro, geothermal, biomass, municipal and industrial wastes). The reequipment, aimed at diminishing the GHG emissions, is also carried out by moving boilers from burning fuels with high carbon content to other sources with less carbon content. As the share of fuels with high carbon content (coal and residual heavy oil) is insignificant in our country, if compared to natural combustible gases, a tremendous effect has been already achieved in such a way. There can be obtained an efficient use of both fossil and non-fossil fuel if: boilers with high profitability are used; cogeneration is applied; heating pumps are used; fossil fuel is substituted by biomass and other renewable energy sources are used.

The rehabilitation of the thermal networks and of the installations for the thermal energy utilization. Network reequipment can be carried out as follows: (I) by using pipes pre-insulated with polyurethane expanded in polyethylene casings installed directly in the soil, without any concrete tubes and with the minimal number of chimneys for visits; (II) by replacing, at the thermal points, of the tubular heat exchangers with the ones with plates; (III) by liquidation of certain thermal points by transferring of the respective equipment within the buildings; (IV) by equiping central thermal points with high quality heat meters.

The consumption of heat can be significantly reduced if energy is conserved directly at beneficiaries. Besides measures implemented in constructions, such as: thermal rehabilitation of buildings, enhancement of spatial and building solutions of buildings, passive usage of sun energy, buildings' heating systems and installations of thermal energy usage should be reequipped as well.

This could be done by actions as follows: (a) equipment of heating installation with thermostat-faucets to individually regulate the thermal regime in each room; (b) using modern heating installations (steel or aluminum panel with wings); (c) using heating systems with low potential (45/30 ^{o}C) through floor or ceiling, using plastic pipes; (d) equipping heating installations with automated systems of functioning regime regulation in accordance with climatic parameters variations (temperature, solar radiation intensity, wind speed) within the exterior environment. An important positive effect could be obtained if meters are installed on the consumers side, and namely to install heat meters at each apartments block and hot water meters in each apartment. Such measures have been successfully implemented in a number of EU countries: in Denmark and France the energy consumed to heat 1 m^2 decreased by 45%, and in certain types of blocks - up to 75%. If losses in the thermal power sector are diminished by 20% only, by 2010 the fuel consumption in urban payments and public sectors will go down by about 200 thousands t.c.e. and GHG emissions - by about 400 thousand tons.

The enhancement and rationalization of the thermical energy systems. The efficiency of the heating systems can be enhanced both via organizational reorganization, demonopolization, privatization, management improvement, as well as via certain technical measures, and namely: (a) placing heat sources in the geographical centers of heat consumption; (b) using in large centralized heating systems a number of heat sources, uniformly placed and linked through circular networks; (c) regulating thermal charges in terms of quantity; (d) enhancing the parameters of thermal bearers.

The potential of GHG emissions as a result of the reequipment of the thermal power sector. The assessment of the potential to diminish the consumption of fossil fuel and emissions of GHG through the reequipment made in the thermal power sector was assessed for the period of 2000-2010. The possible amount of fuel possible to be saved is over 500 thousands t.c.e. per year, that is, 9% of country's total consumption of energy, or some 50-60 mil. USD annually saved for the purchase of energy and electricity (according to data of the Moldovan Ministry of Economy). If all planned actions of reequipment in the thermal power sector are implemented, GHG emissions will be diminished by about 1.1 mil. tons.

The transport sector

In a developing economy, where the economic decline has not been stopped yet, there is a considerable uncertainty in assessing the potential of diminishing emission of greenhouse gases in the transportation sector through implementation of high-tech in this sector. At present, increase in energy efficiency and decrease in fuel consumption represents the most real possibility to diminish GHG emissions resulting from the transportation sector. This can be carried out as follows: (I) by gradual reduction in operating terms - from 7 to 4-5 years - for vehicles since their import; (II) granting preferential credit for the purchasing economic means of transport (having a high efficiency and low fuel consumption); (III) using more widely railways, naval and maritime transport; (IV) electrifying the railways and reconstruct Ravaca - Cainari railway segment, it will decrease twice the portion of the line, in comparison to the existing one Ravaca - Tighina - Causeni - Cainari, and, consequently, the fuel consumption will decrease twice, as well; (V) pushing the transit transport out of cities; (VI) enhancing transport timetables, keeping relatively constant circulation speed; (VII) developing public transport networks, including the electric ones (trams and trolleys); (VIII) enhancing parking lots in large cities; (IX) encouraging imports of high quality fuel.

As per certain assessments, the following main measures could lead to a reduction in emissions of greenhouse gases by 10-15% of the current emissions registered in the transport sector (110 - 170 Gg): (a) renew the fleet of rolling stock so as to use transportation units with economical fuel consumption; (b) repair, modernize and maintain in good service the network of roads; (c) electrify railway portion of line Razdelnaia - Ungheni; (d) reconstruct railway sector Ravaca – Cainari; (e) build a highway belt around the municipality of Chisinau; (f) develop electrified networks of public transport in urban localities. These measures call for huge investments, therefore they could be implemented over the next 5 to 7 years.

Other measures, less expensive, could contribute to a reduction in GHG emissions by about 3-4% of the current emissions in the transport sector (some 35-45 Gg). It is meant the following: (a) increasing the amount of goods transported via railway or sea; (b) establishing the so-called "green light" for the communication ways where the traffic is controlled by traffic lights; (c) applying certain economic measures and tax policies to encourage the renewal of the fleet of rolling stock; (d) enhancing vehicle parking in cities and facilitate the use of public transport.

However, considering the technical state of the fleet of rolling stock and the fact that it will be renewed gradually, the quality of communication ways being the same or rather continuously degrade, we could expect a slow escalation in fuel consumption as, consequently, of greenhouse gases emissions. If the economic situation is improved, this enhancement could be greater, especially in the case of unintegrated approach to environmental and sustainable development issues.

The renewable energy sources

The potential of the GHG emissions abatement through the utilization of wind installations. "Draft frame designed of the Republic of Moldova on renewable energy sources implementation" stipulates that by 2010 2% of the total consumption of primary energy, that is about 130 thousands t.c.e. per year, be generated by wind. We believe that, for an optimal specific consumption feature of up-to-date CHPs worth 0.35 kg.c.e./kWh, 370 mil. kWh/year of electric energy correspond to the this amount of fuel. Replacing a part of the electric energy produced at CHPs with the energy produced at wind plants, a considerable environmental benefit will be achieved, avoiding the emission of over 260 thousand tons of CO_2 and some 2 thousand tons of SO_2 and NO_x, which have a severe negative impact on the population's health. At the same time, acid rains containing these elements causes the degradation of forests and agricultural produce. The damages produced by SO_2 and NO_x emissions are estimated at 6,000 Euro/year. Consequently, there will be a 12 mil. Euro/year extra benefit as a result of avoiding the above-mentioned emissions. The respective decrease in electricity import will increase the state energy security.

The cost of the measures for the GHG emissions abatement through the implementation of the wind energy. In order to implement the frame designed with respect to electric energy production at wind plants, amounting to 370 mil. kWh/year (by 2010), it will be necessary to build wind plants wit a total installed capacity of about 120 MW. It was considered that air-generators with 0.6 - 2 MW nominal power with the height of the tower of 70-90 m will be used, in order to guarantee, under the local meteorological conditions, the most favorable location on the territory of the republic (utilization coefficient of installed power – k_u = 0.35). As per computations, done through the general methodology used for such energy objectives, total investment equal to cca 120-150 million USD are required or specific capital investments equal to 1,000 – 1,250 USD/kWh, including the cost of air-generators, construction of civil and electric infrastructures, expenses for transportation, setting-up, and putting into operation.

The potential of the GHG emissions abatement through the utilization of solar installations. The potential to diminish GHG emissions and replace fossil fuel through the use of solar installations is assessed for: water heating in the rural sector; fruits, vegetables, and herbs drying; water pumping for small irrigation and electric energy supply to anti-hail stations. The National Strategy for Sustainable Development stipulates for 2010 a 10% share of RES in the total energy consumption, that it, 650,000 t.c.e. It includes the energy obtained at hydro-electric plants from winds, biomass, and sun energy (2.3% of the total energy consumption or about 150 thousand tons per year). At the same time, replacing a part of the thermal and electric energy produced by solar installations for water heating, fruits, vegetables and herbs drying, PV installations for water pumping and electric energy supply to anti-hail stations, the quantities were assessed of CO_2 emissions avoided on yearly basis as a result of using the solar energy (about 317 thousand tons). Taking into account the additional economic benefit, attained by avoiding damages to the environment and public health, both external expenses, and the cost of using the traditional energy sources will be avoided.

The utilization of the solar energy for water heating in the rural sector. On the basis of the specific demand for thermal energy and of the data regarding the installations' output, the specific GHG emissions and the caloric power of the fuel, there were assessed the amounts of the fossil fuel substituted by solar energy in the units of conventional fuel – 120.4 thousand t.c.e., as well as the GHG emissions reduction – 242.6 thousand tons per year. In order to achieve these GHG reductions, it is necessary to install about 1.6 mil. m^2 solar collectors by 2010. Thus, a family of the rural sector will need an autonomous solar installation with a collector of about 3.8 m^2.

Solar installations for the drying of fruits, vegetables and medicinal plants. At present about 1,500 t of fruits and vegetables are dried annually, which represents only 0.8% of fresh fruits and vegetables. The real potential is ten times larger, of about 15 thousand tons of dried products. As the price for fuel has risen, production in this sector was cut. Diesel oil is used for drying, and the electric energy is used to assure air circulation. About 50% of the necessary thermal energy can be substituted with energy. In such a case, there is a potential to diminish GHG emissions by 9,150 t/year, and the potential to substitute the diesel oil can be as much as 2,900 tons (4,140 t.c.e.). The total area of solar collectors is about 80,000 m^2.

Pumping installations for the small irrigation. Via the Government's Resolution No. 256 dated 17.04.2001 "On the repair of irrigation systems for the period of 2001 - 2008". The small irrigation has a total capacity of 36 thousands ha or 22% of the total irrigable territory of 160 thousands ha. The 3,000 reservoirs, lakes, etc, out of which 411 are the most important, will be used as water resources. It was admitted that PV sun energy be used to irrigate 35% of the territory stipulated in the Program, with a total manometric height of 40 m. The computations were done in comparison with the supply of pumping installations from a power network or from an electrogenic group on Diesel oil. The difference between these two alternatives – about 4 times – is due to the higher efficiency of energy conversion in the case of supply from the network. At the same time, the electrical network is spread over a distance of 1 –2 km., the cost is 2-4 times larger than of an electrogenic group. The utilization of pumping installations for the small irrigation on the basis of the PV modules will permit to economize cca 10.8 thousand tons t.c.e., and to reduce the direct GHG emissions with cca 23.8 thousand tons yearly.

The installations for electric energy supply to the anti-hail stations. At an anti-hail station they substitute liquid fuels (Diesel oil or gasoline) needed for the transportation of storage batteries to charge stations and the electric energy used to recharge them. In addition, the quantity of noxious wastes will diminish by 5.6 t/year as a result of storage batteries repair. The computations were done for the existing 150 stations. It is considered that a season runs from April to September. The cost of measures have been determined as the ratio of annual investments to the annual quantity of GHG emissions expressed in tons. The obtained results indicate the fact that there may be economized cca 16.3 t.c.e yearly, and the direct GHG emissions may be reduced with cca 36 tons as a result of the traditional energy sources substitution by the PV installations for the electric energy supply to the anti-hail stations.

The cost of the measures for the GHG emissions abatement through the utilization of solar installations. The costs of measures for the GHG emissions reduction were assessed for four types of solar installations: for water heating, for farm products drying, for small irrigation and for anti-hail stations. The highest costs of measures aimed at diminishing GHG emissions are incurred at PV solar installations used for small irrigation – cca 3,000 USD/ha, a fact explained through significant investments in photovoltaic energy. Respectively, the lowest costs are incurred by solar installations for fruits and vegetables drying - cca 60 USD/m^2. At the same time, it should be mentioned that the implementation of these two types of solar installations brings the highest social and economic benefits: new jobs are created in the rural sector; export possibilities raise; the processing industry is assured with raw material; food and state security strengthens; the dependence of agricultural produce on climatic factors decreases.

The potential of the GHG emissions abatement through the utilization of biogas installations. The total volume of the biogas recoverable from different sources of biomass consists of: animal dejection – 19,116 thousand m^3/year; sludge and mud from communal treatment plants– 22,000 thousand m^3/year; industrial used waters with high content of organic substances – 14,705 thousand m^3/year. The following amounts can be recouped among SMW: from equipped landfills – 3,125 thousand m^3/year; through "Valorga" wet process – 69,300 thousand m^3/year. About 125 thousand m^3 of biogas, estimated at 62.5 thousands t.c.e., can be annually recovered through anaerobic fermentation of organic wastes. In other words, this equivalent will conserve annually energy obtained from fossil fuel and, respectively, methane emissions will decrease by about 75 thousands t/year, representing about 1,575 thousand tons of CO_2 emissions equivalent.

The cost of the measures of the GHG emissions through the utilization of biogas installations. The technico-economic indices for the biogas installations for mud and liquid animal dejection fermentation depend on the type of the anaerobic fermenters used *(the capacities between 250-1,500 m^3).* In these conditions, the values of the total investments required will vary between 116-246 million USD.

POLICIES AND STRATEGIES. THE POWER SYSTEM AND THE ENVIRONMENT

Politics and Strategies in the European Union

The sustainable development of the society, as well as the environment concerns, are two fundamental objectives of the European Union – stipulated in the Treaty of the European Union. The increase of the energy dependence on the energy resources import is another major concern of the EU. At present, the Member States import about 50% of the necessary energy. In this way the European Commission decided to reconsider the fundamentals regarding supplies of the European Union with energy resources, initiating an ample debate concerning the elaboration of a strategy on diminishing the external energy dependence. This subject, of special importance, represents the quintessence of a new document the European

Commission and named The Green Paper – Towards a European Strategy for the security of Energy Supply.

In 1998 the European Commission published the Communiquй concerning the energetic efficiency: "Towards a strategy for the rational energy consumption". In 2000, a Plan of Actions to improve the energetic efficiency has been initiated [14], this document making up a logic development of the previous Communicate of the commission. The European Union policy in the sector of the renewable energy sources is based on the respective Community Strategy and the Plan of Actions until 2010 [16]. The main supporting and monitoring instruments of the strategy in the sector of the renewable energy sources are: the Altener Program and the "take-off" Campaign.

As fundamental objectives, settled for the integration of the environment aspects in the Energy Strategy of the European Community (1998), the following has been established: promoting the energetic efficiency and conserving the energy, the full utilization of the renewable energy sources and the diminution of the producing energy sources impact on the environment. In 1991, the first EU strategy concerning the limitation of the CO_2 emissions, the improvement of the energetic efficiency and the renewable energy sources promoting; in accordance with the decision of the European Council 99/296/EC of 26.04.1999 (amendment to the decision 93/296/EEC of 24.06.1993) the revision and improvement of the monitoring of the CO_2 and other GHG emission had been approved. With a view to respect its obligations from the framework of the UN Framework Convention on Climate Change, in March 2000, the European Commission initiated the European Climate Change Program (ECCP), this way facilitating the strategies elaboration, as well as the elaboration of the emissions marketing scheme, to assure, in the period 2008-2012, the GHG emissions diminution with 8% - as stipulated in the Kyoto Protocol. As a logic continuation of the undertaken by the UE was the ratification document of the Kyoto Protocol in June 2002.

Policies and strategies in the Republic of Moldova

One of the most important energy policy documents is the long-term energetic Strategy of the country that shows the priority directions of developing the energetic sector and the settled objectives for a far horizon. Taking into consideration the long-term development, the energy sector will need a re-modeling, in accordance with the stipulations of the "Long-term Development Strategy – Moldova 21".

The strategic aspect of the Republic of Moldova adhesion to the European Union concerns the realization of the Art. 60 "Energy" of the Partnership and Cooperation Agreement between the European Community and the Republic of Moldova. The co-operation will take place on the basis of the market economy principles, of the European Chart for Energy principles and on the background of the progressive integration of the Europe energy markets. The necessity of promoting a unique policy in the environment and using the natural resources spheres, of implementing the ecological demand in the national economy renewal process, the political orientation to the European integration – all these conditioned the revision of the environment policy and the elaboration of a new conceptual document in this sector. In this way, the Concept of the environment politics of the Republic of Moldova (approved by the Resolution of the Republic of Moldova Parliament nr. 605-XV, of the 5th of November 2001) had been elaborated to connect the major objectives of the ecological policies to the social-economical changes of the country, to the regional and world programs and tendencies in this sector, for preventing the degradation of the environment. The Republic of Moldova is more and more actively joining the promoted by the UNFCCC. The First National Communication under the UNFCCC that includes the GHG emissions inventory and estimations concerning the social-economic impact of the GHG emissions effect had been improved and submitted. Signing the Kyoto Protocol is being prepared, so that the promoted activities correspond to the stipulations of the environment policy Concept, in which the necessity of "implementing the stipulations of the United Nations Framework Convention on Climate Change and those of the Kyoto Protocol" is stipulated.

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1.1. Structure and current state

The energy sector makes an integral part of the national economy, which provides for production, transportation and distribution of electrical and thermal energy for the housing, public and industrial sectors.

The energy sector of the Republic of Moldova consists of:

– Electrical power sector;

– Thermal power sector;

– Solid, liquid gas and fuel supply sector.

The main objective of the energy sector is to supply the country with electrical and thermal energy, and fuel. The energy sector has a vital role in the economy and consumes on yearly basis about 40-60 percent of the overall fuel consumed in the country.

In the Republic of Moldova, the energy sector was created during the period of 1950-1980 in condition of centralized economy. In technical terms, the energy sector evolved towards increasing the unit power of the installations to produce and transport of energy and charging small prices for consumed fuel and produced energy. This state of affairs was supported artificially through huge subsidies from the state.

The main feature of the energy sector that was formed during that period of time, was a high degree of centralization: for the cities of Chişinău and Bălți – about 85% of the thermal power supplied was from the centralized heating systems, whereas in the small towns with populations varying between 22 and 50 thousand inhabitants, this index varied between 55 and 68% (Floreşti – 55%, Ungheni – 60%, Orhei – 65%, Soroca – 68%) [1].

During the recent 10 years as an outcome of reforms, in the Republic of Moldova a profound decrease was registered of all both economic and social indicators. The specific trait of the Republic of Moldova, in comparison with other post-soviet countries, was manifested at that time by political instability and territorial secessionism, a situation that implied extension of shadow economy in comparable with the official one. This negative phenomenon, in line with structural dis-equilibrium typical to transition countries, provoked a continuos economic decline and pauperization of the population (in 2000 the average salary was only one third of the minimum consumption budget, and GDP made up about 34% of the level registered in 1990).

In the period under review (1990-2000), the economy of the country was severely affected due to destruction of the economic potential and insufficiency of both domestic and foreign investments, particularly in industry (the share of industrial sector as added value in the GDP structure, which in 1993 made-up 39%, by 2000 decreased up to 17.5%). An extremely complicated situation was in the national energy sector, characterized by the following significant factors:

– Outdated and highly depreciated energy equipment and installations: about 60% of the thermo-electrical installations are older than 25 years, 40% - 30 years old.

– Low level of the provided services and decreasing energy efficiency.

– High energy intensity, of 3-4-fold higher than the respective indicators in the developed countries. The Republic of Moldova ranks among the countries with the highest share of expenditures for the electricity consumed.

– High dependence on the imports of primary electricity (about 98%).

– A limited number of suppliers of fuel and electrical energy; natural gas are purchased from one country.

– The share of natural gas in the structure of overall consumption of electricity accounts for about 60%.

– The low level of the capacities to generate electricity for covering the consumption needs – only 30% on the right bank of the river Nistru.

– Low capacity of the electrical lines for connection with the Western side (only 3 lines of 110 kV); structure of the networks does not favor the energy security of the country.

– The growing trend of indebtedness. Financial blockage of energy enterprises caused by high rate of both accounts payable and receivable. Growing almost twice of energy and fuel losses, during last years (in the electricity sector this amount exceeded 30% of the overall amount of supplies).
– Lack of capital investments for rehabilitation and development of respective sector.

In the mid-term perspective, the activities in the field of energy sector in the Republic of Moldova will be guided within the *Energy Strategy of the Republic of Moldova until 2010,* which stipulates further improvement of the legislation aimed at promoting the principles of market economy (demonopolization, competition, involvement of private capital, transparency), principles that need to be respected for the purpose of integration of the Republic of Moldova in European Union (*Box 1.1*).

1.1.1. Electrical power sector

The electricity sector is that part of the energy sector, which provides for production, transportation, distribution and supply of the electricity to consumers. In the Republic of Moldova the electricity sector is constituted of:

– enterprises producers of electricity;
– enterprises of energy transportation;
– distribution enterprises;
– state enterprise "Moldtranselectrica".

I. Enterprises producers of electricity

In the Republic of Moldova there are the following sources generating electricity:

a) Thermo-Electrical Power Plant (TPP) with condensation - Moldovan TPP.
b) Cogeneration power plants: Combined Heat Power Plants (CHP), CHP-1 and CHP-2 Chişinău and CHP-North Bălţi.
c) Hydroelectric plants, Costesti and Dubăsari.

a) Moldovan TPP from the town of Dnestrovsk:

Moldovan TPP was built between the years of 1964-1980 and avails of 12 energy units with a total installed capacity of 2520 MW, the available capacity being about 950 MW. The main fuel for units 11 and 12 is the natural gas, for units 9 and 10 – residual fuel oil, the coal being the fuel for the energy units 1-8. The wear degree of the equipment varies: this indicator is very advanced – of about 80% for units 1-8, which were set up during the years of 1964-1971 (during the period 1998-2002 none of them functioned, all of them having been conserved). The wear degree of the energy units 9-12, which were built during 1974-1980 is estimated at about 50%.

b) cogeneration power plants:

CHP-1 from Chişinău was built within 1951-1961 period. It has an installed capacity of 46 MW, the available being about 40 MW. The main fuel is natural gas, and the reserve one is residual fuel oil. The wear degree of the equipment is about 60%.

CHP-2 Chişinău has an installed capacity of 240 MW, and available one being of 210 MW; it was built between 1976-1980. The main fuel is natural gas, and the reserve one is residual fuel oil. The wear degree is of about 50%.

The CHP North-Bălţi, with a installed capacity of 28 MW and an available power of 24 MW was put into operation in 1960. The main fuel is natural gas, and the reserve one is residual fuel oil. The wear degree of the equipment is about 60%.

The CHPs of the sugar factories with a total capacity of about 90 MW serve as seasonal energy sources (Alexăndreni – 12 MW, Briceni – 12 MW, Cupcini – 12 MW, Donduşeni – 10 MW, Drochia – 10 MW, Făleşti – 7,5 MW, Gârbova – 12 MW, Ghindeşti – 6 MW, Glodeni – 10 MW). These CHPs were put into operation between the years of 1956-1985, so that their degree of wear differs from one station to another. The installed capacity of these CHPs depends on the volume of production of sugar, being estimated at about 20 MW.

c) hydro-electrical plants

The hydro-electrical power plant from Dubăsari was put into operation in 1954, having an installed capacity of 48 MW, an available capacity of 30 MW and a wear degree of about 75%.

The hydro-electrical power plant from Costesti has a installed capacity of 16 MW, the available capacity being of about 10 MW and the wear degree of 67%. It was put into operation in 1978.

II. Enterprise of energy transportation

The state enterprise "Moldelectrica" for energy transportation was created based on Government Resolution no. 1000 dated October 2, 2000, according to which from the state enterprise "Moldtranselectro" there was taken over the infrastructure for electricity transportation, the central dispatching center and the training center. "Moldelectrica" operates as system operator, keeps and manages transportation networks of 110 to 400 kV (to transport the energy to long distance destination).

The main transportation lines (*Annex 1.1*) are:

- Overhead electrical line (OEL) 400 kV Moldovan TPP – Vulcanesti – Isaccea (Romania);
- OEL 330 kV on the route Moldovan TPP - Chisinau – Balti – Donduseni.

The electricity system of the Republic of Moldova is connected with the Ukrainian system through 7 OEL of 330 kV and 14 lines of 110 kV, being interconnected with Romania through 3 lines of 110 kV (*Annex 1.1*). The wear degree of these lines varies from 40 to 60%.

III. Distribution enterprises

The distribution network has several stages of voltage (380 V, 10 kV and 35 kV). In the distribution networks voltage decreases from 35 kV per 10 kV, and subsequently from 10 kV to 0.4 kV. The rough the network of 0.4 kV the electricity is distributed to the enterprises, commercial centers and consumers of the housing sector. The increase and decrease of the voltage occurs at 193 transformation stations of 10-400 kV.

From territorial point of view, the distribution networks are represented by the lines of 0.4 kV and 10 kV of the Joint-Stock Company (JSC) EDN North, JSC EDN North-West and those in the ownership of the Spanish company "Union Fenosa" (JSC EDN Center, JSC EN Chişinău and JSC EDN South). The wear degree of these networks is estimated at approximately 60-70%.

In the early 2000 three electricity distribution companies (Electrical Networks (EN) Chişinău, EDN Center and EDN South) were taken over by the Spanish Company "Union Fenosa". This influenced to a great extent the evolution of the situation in the electrical-power sector in the service zone of the company "Union Fenosa" (about 70% of the territory of the country). Currently, there is a continuous supply of electricity, settlement of debts for the consumed electricity, a better collection of the current payments and total exclusion of barter and reciprocal payments as ways of payment.

On monthly basis, the company "Union Fenosa" distributes through EN Chişinău, EDN Center and EDN South about 70-75% of the overall electricity that is consumed in the country. The other share of the electricity 25-30% is supplied by JSC EDN North and EDN North-West (*Figure 1.1*).

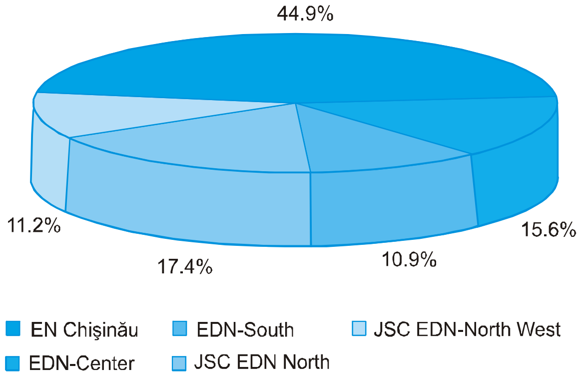

Figure 1.1. *Share of EDNs in supplies of electricity (September 2001), mil. kWh*

In 1990 the total length of the electrical lines was estimated at about 76 thousand km. Since 1994 the transportation networks placed on the left bank of the river Nistru are managed by the enterprise "Dnestrenergo". As a result, the data presented in the Table 1.1 for 1996 refer only to the right bank of the river Nistru.

Table 1.1. *The length of the transportation networks, km (situation as on 01.01.1997)*

kV \ Year	1990	1992	1994	1996
400	*214*	*214*	*214*	*202*
330	*530*	*530*	*530*	*375*
110	*3,962*	*4,058*	*4,200*	*3,109*
35	*2,403*	*2,370*	*2,370*	*721*
10	*29,484*	*29,435*	*29,435*	*25,357*
0.4	*39,429*	*39,344*	*39,344*	*33,901*
Total	**76,022**	**75,951**	**76,093**	**63,665**

During the period 1996-2000 due to natural calamities (landslides, floods and massive laying of hoarfrost) a part of the networks were damaged (about 2-4 thousand km), and only partially restored.

IV. State enterprise "Moldtranselectro"

The state enterprise "Moldtranselectro" was created in 1997 by decentralization of the former State Company "Moldenergo". At present the main objective of this enterprise is to manage the historical debts of the electricity sector.

1.1.2. Thermal power sector

The thermal power sector represents that segment of the energy sector that is employed in production, transportation and distribution of the thermal power, and is constituted of the sources of thermal power and thermal networks.

The thermal power sector was created during the time span of 1950-1970, and supplies with thermal power for the urban localities used to be performed mainly based on the autonomous heating systems. The essential growth of the prices on the world market for oil products and other fuels that are used in the energy sector, particularly after the energy crises from 1973, contributed to promotion and development of the centralized systems. The main sources of thermal energy for centralized systems are CHPs, municipal, urban and industrial thermal plants (TPs). In these systems, the concentration of the thermal power into one power plant allowed to reduce considerably the operational costs, thus contributing to diminishing environment pollution by erecting the factory stack. The high capacity boilers that are used at present too, are highly automated and productive, in comparison with those from the autonomous systems for thermal power supply, which used to exist before 1960-1970. It is worth mentioning that nevertheless, the thermal plants, with minor exceptions, are older than 20 years, whereas others even over 30-40 years.

Currently, the thermal-power sector of the Republic of Moldova is represented by:

- Large centralized heating systems.
- Local centralized heating systems.
- Autonomous heating systems.

I. Large centralized heating systems

The category of large centralized heating systems comprise power systems from the municipalities of Chisinau, Balti, Orhei, Soroca, Ungheni, Floresti and those from towns of Donduseni, Glodeni, Briceni, Cupcini, Drochia and Falesti, which are supplied from the CHPs of the sugar factories. The large centralized heating systems are composed of:

- sources of thermal power (CHPs and TPs);
- plants and network-pumps (basic and intermediary);
- thermal networks for transportation and distribution of the thermal power (thermal carrier, including technological steam);
- thermal stations for interconnection of main networks and secondary (local) ones.

In the large centralized heating systems, the energy sources are represented by CHPs and TPs of high capacity. CHP – 1 and CHP – 2 from the municipality of Chisinau and CHP-North from the municipality of Bălți operate as autonomous economic units. The CHPs of the sugar factories are parts of the respective factories, and large TPs, jointly with the adjacent infrastructure, in most of the localities form JSCs with state share capital. For example in Chişinău, the JSC "Termocom" comprises 4 large TPs (TP West (Sculeni), TP Muncesti, TP South, TP East) and a series of TPs both medium and small.

The designed regime for centralized supplies of thermal power was chosen in compliance with the level of temperature of the thermal carrier (150-70C^0) and warm water (70C^0). The distribution principle is based on a constant flow and does not allow individual control of heating to each consumer. The temperature level, and respectively the thermal carrier are regulated at the energy sources by up-keeping constant volume thereof. The only possibility to change the temperature in the system of buildings is to regulate the debit of the thermal carrier on the point of its elevation of the block of flats.

The main pumping plants are placed at the sources of thermal power (CHPs and TPs). In the large heating networks from the localities with varied relief, such as, for instance, the municipality of Chişinău, intermediary pumping plants are installed.

The absolute majority of the thermal networks are aged over 25 years and are executed based on an out-dated technical-scientific concept –

with overlapped insulation, underground placement in concrete canals (without possibility of access) and in tunnels (with possibility of access). In the zones with a high level of phreatic waters there are sectors of networks on the surface. In Chişinău, for old pipes, for insulation glass cotton-wool coating and layers of asbestos have been used. In other cities the pipes are insulated with metal plates and mineral lining of cardboard embedded with pitch.

The thermal power is transported through the main networks to the so called central thermal stations, then through external distribution networks to the individual thermal points, where the secondary thermal carrier is prepared, for internal heating installations. The main networks consist of double pipes – for the two-way flow of thermal carrier. On network segments, where the directions of the steam and warm water pipes coincide, the main thermal networks comprise four pipes: hot water (two-way) and steam/condensed for industrial consumption. In 1990, an year with a maximum volume of thermal energy production, the overall length of the thermal networks made up about 1900 km (*Table 1.2*).

Table 1.2. *The structure of thermal networks (1990)*

Diameter of the pipe, mm	Length of the pipes, km
Up to 200	*1,590*
200 – 400	*220*
Over 400	*90*
Total	**1,900**

During the last 10 years a continuos trend has been noticed of decentralization of the large heating systems; this factor, however, did not affect the length of the thermal networks. At present partial replacement is taking place of the old networks with new ones. For instance, during the renovation program of the heating system in the city of Chişinău, financed by EBRD, there were replaced some segments of pipes from the concrete canals with pre-insulated pipes placed right on the soil. Also, the pumping plants and central thermal stations were endowed with new pumps, being installed up-to-date heat exchanges for heating and water at the central thermal stations, as well as 463 thermal power meters with the consumers [1].

At present, in Chişinău the total length of the main thermal power networks in 2 pipes with a diameter of 50-120 mm is of 538 km; the length of the secondary distribution networks (in 3-4 pipes) amount over 520 km, and that of the steam pipes with a diameter of 50-500 mm – over 25 km. The Chisinau thermal networks comprise 509 thermal stations that separate main thermal networks from the secondary (local) ones and 22 intermediary pumping plants. The total length of the thermal networks from other localities of the country is as follows: Bălţi – 123 km; Soroca – 33 km; Ungheni – 24,5 km; Orhei – 23,8 km and Floreşti – 17,4 km.

The thermal plants comprise also collectors of water distribution (two-way), heat exchangers, designed for heating housing water and, in some cases, pumps for increasing the pressure of the hot water. Initially, in compliance with the technical requirements, all the thermal stations were furnished with electric pumps with automated temperature control, a fact which allowed to re-utilize hot water; later, however they were quashed. For consumers this fact implied direct economic losses, given that in the time period when the hot water is not used, the pipeline cools down.

The heat exchangers are tubular in countercurrent. Recently, in Chişinău, the tubular heat exchangers were replaced by up-to-date exchangers with slates. The thermal stations of the enterprises, which are supplied with steam, are equipped with exchangers of steam/water.

It is worth mentioning that the thermal networks in the industrialized countries allowable losses of heat at nominal regimes (depending on the length of the network, debit of water compared with the calculated one, temperature regime, diameter of the pipes, etc.) constitute 8-15%, and water losses – 0.5-1.5%. As comparison, one could mention that according to a recent study, in Chişinău, during the heating season the heat losses are estimated at 20-25%; water losses – at about 15%. In the thermal networks from other localities of the country, characterized as being in a deplorable state (the latter functioning at a capacity much below the designed one), the heat losses are much bigger.

II. Local centralized heating systems

Local centralized heating systems can be attributed the systems of local, or district TPs and TPs of large industrial enterprises (for e.g. those of the JSC "Bucuria", JSC Pielart, JSC Franzeluța, Furniture Combined Works "Codru", Ferrous Concrete Plant, JSC "Macon", etc.). Usually these TPs use only one kind of fuel.

Local thermal plants are placed in small towns furnished with hot water boilers, based on consumption of natural gas and solid fuels, whereas the industrial ones – natural gas or residual fuel oil. From these thermal plants administrative buildings, residential blocks of flats, and surrounding houses are supplied. Given that the thermal networks from the local centralized heating systems are placed on a relatively small area, the thermal plants, in most cases, are not needed, and in this case the network pumps and the exchangers for warm water production are placed directly on the source of thermal energy.

The energy sources are not furnished with installations for chemical treatment of the water, and the boilers that operate based on solid fuel are not designed with installations for ash collection. The factory stacks are 30m high, and with the older thermal plants they are 20m high.

Losses of heat and water in the local centralized heating systems are much smaller than in the large centralized heating systems. This is explained by the short length of the thermal networks and reduced operation and maintenance costs. The consumption of electricity for heat transportation in the local centralized systems constitutes 0.5-5.0 kWh/GJ, and in the municipality of Chişinău this indicator reaches 15 kWh/GJ.

Usually, the thermal plants of the industrial enterprises are furnished with steam boilers with capacity of 1-6 t/h. In comparison with local thermal plants, those belonging to industrial enterprises, usually, have installations for chemical treatment of water. The installations for purification of natural gas are missing, the stack being of 30-50m high.

The current situation in the centralized heating systems is extremely complicated (*Box 1.2*).

Box. 1.2. *Main factors that implied the bankruptcy of the centralized heating systems*

– The heating sources of the centralized heating systems, as well as the transportation and distribution networks form old systems, are technically outdated and obsolete.

– The sources of heating are not placed rationally in geographical terms, and a big deal of consumers cannot be connected thereto.

– The span of the main networks is too large, which implies increasing losses and transportation costs.

– It is neglected the need of up-keeping and developing the thermal networks, the temperature schedule (150-70 C^0) being non-respected.

– The equipment for up-keeping the hydraulic regime is destroyed or is highly depreciated, a fact which implies essential reduction of quantity and quality of the thermal carrer transported towards the consumer.

– After the installation of individual thermal power plants and energy meters with a small flow it formed hydraulic resistance, or which lead to additional increase of the transportation costs of the thermal carrer.

– As a result of the incapacity to maintain and renew the distribution thermal networks the hydraulic regulation thereof becomes impossible and imply adequate supplying with thermal energy of the housing blocks of flats from the urban localities.

– The reduced volume of the supplied thermal power, permanent water leakage in the basements of the residential houses and missing equal conditions for internal distribution, determines the increase of the level of phreatic water, extending anti-sanitation zones, emergence of mould on the interior surfaces, rotting windows and, in the end, rapid destruction of the residential areas.

– Inappropriate tariff policy and formation of the intermediary services for collecting payments consequently led to a low level of settlement of arrears.

Conclusion:

Degradation of the thermal networks, lack of interest in maintaining and developing thereof, excessive losses in all the segments of the centralized heating system and insolvency of the consumers caused the bankruptcy of the centralized heating supply systems.

III. Autonomous heating systems

An autonomous system for heating consists of the thermal plant and internal networks of the consumer. The heating sources from these systems represent the thermal plants of small capacity; before 1990 they were installed only in the buildings situated at long distance form the centralized heating systems or in localities where they were missing. Given that, as a result of the additional costs for thermal power transportation through large networks of the centralized heating system this is more expansive than that supplied by autonomous heating systems, many consumers disconnect from the thermal plants and install autonomous heating systems. The main factors, that influenced this process are as follows:

– fast increase of energy prices;

– diminishing quality of the services rendered by the large centralized heating systems;
– emergence on the national market of the up-dated energy equipment (boilers of small productivity).

In comparison with the large centralized heating systems, and local ones, the autonomous heating systems present a series of advantages, such as:

– total independence from external factors (power plants, thermal power networks, other consumers, etc.);
– absence of thermal networks, respectively of losses in the network and operation and maintenance expenditures;
– higher productivity of the thermal power plants (TPs), in case when the boilers are installed within the premises of the buildings (almost no losses are registered).

In these conditions, in order to provide for necessary framework for efficient functioning of the thermal power sector, in the *Energy Strategy of the Republic of Moldova until 2010,* new objectives were drawn-up for development of the heating systems (*Box 1.3*).

Box 1.3. *Main objectives for further development of the thermal power sector for the mid-term period*

– Decentralization of the existent thermal power sector and commissioning thereof to ownership and management of the local governments, by reserving the possibility for subsequent privatization of certain thermal power objects;
– Promoting further development of both centralized and local heating systems for thermal power supply based on "cost-benefit" principle;
– Promotion of co-generation of thermal and electricity, within CHPs, with the purpose to enhance the efficiency of the utilization of primary energy sources, based on the "cost-benefit" principle.

1.1.3. Gas, solid and liquid fuels supply sector

In the Republic of Moldova natural gas reserves are concentrated in the gas deposits from the locality of Victorovca, its volume being estimated at approximately 9.8 mil m^3. The possibilities to explore this deposit are limited. In these conditions, the supply of natural gas to Moldova is carried out, at present, exclusively by imports from the Russian Federation. The main importer of natural gas is the JSC "Moldovagaz", which purchases over 90% of the total volume. The share of other importers of natural gas – Gaztex, Hendrix Enterprises JSC., Glob Universal Ltd., Energoimpexgroup JSC., Hostex Establishment Company, Alfa Engineering Group INC, NII "Vsemirny Dom", and "Itera" is small – only 6.6%.

The Republic of Moldova is crossed by international pipelines with a total length of 730 km. The total length of the gas distribution pipelines in Moldova is about 4400 km, and the international gas pipelines are represented on the following segments (*Annex 1.2*):

– Ananiev (Ukraine) – Râbnița – Şoldăneşti – Chişinău.
– Ananiev (Ukraine) – Râbnița – Bălți – Drochia – Ocnița – Alexeevka (Ukraine).
– Odesa (Ukraine) – Tirsapol – Vulcăneşti – Orlovka (Ukraine).

The Republic of Moldova is crossed by international gas pipelines with considerable capacity. For instance, in the period of 1994-1999 the volume of natural gas transited to the Balkan countries (România, Bulgaria, and Turkey) varied between 15.7 bil. m^3 (1994) to 22.4 bil. m^3 (1996). At present the share of transportation capacities' employment is estimated at 1/3 of the maximum capacity. The un-utilized capacity leads to economic losses, insofar as, regardless to the level of employment, the entire equipment is exploited, the costs being similar as in case of maximum exploitation of the equipment.

In the period of 1990-1999 the annual volume of imports varied between 3.87 bil. m^3 and 2.86 bil. m^3, with a maximum level of 3.87 bil. m^3 in 1991 and a minimum volume of 2.86 bil. m^3 in 1999. On the right bank of the river Nistru, the annual volume of imports of the natural gas was of about 1.5 bil. m^3 (maximum – 1.71 bil. m^3 in 1994 and minimum – 1.23 bil. m^3 in 1995). In the future the Republic of Moldova could consume annually up to 5-6 bil. m^3 of natural gas.

Box 1.4. *Main objectives of the development of the natural gas supply sector for the mid-term*

– Construction of the main gas-pipeline Căuşeni-Chişinău, Drochia-Ungheni-Iaşi and gas supply to the localities that have not been provided natural gas before.
– Finishing the process of installation of meters on consumers' side, providing for meters installations at the borders of the republic for gas transportation though the main pipelines, as well as meters for intra-system branches.

Having into account the increasing demand of the natural gas in most localities of the country and missing financial possibilities of the state to meet this demand, *The Energy Strategy of the Republic of Moldova until 2010* sets the objective on developing the natural gas networks and ways to implement them. According to this document, the above mentioned objectives will be reached with the participation of the private capital and based on tender procedure (*Box 1.4*).

The Republic of Moldova avails of its own reserves of lignite that may be used in the future as fuel. Thus, the reserves from Briceni and Vulcanesti are estimated at 18 mil. tons, and those from Cismichioi – at 16 mil. tons. These deposits represent profound strata of about 500m with a content of the ash varying between 12 and 40% and a caloric power of 6,000-7,000 kcal/kg.

From economic viewpoint, the exploitation of the respective deposits is not profitable at present. The main suppliers of coal of the Republic of Moldova are Russian Federation and Ukraine. Coal has been one of the main types of fuel for the Republic of Moldova, and in the last years the share thereof in the energy balance of the country has diminished considerably. This occurs due to an essential reduction of the consumption of solid fuel by Moldovan TPP and by the housing sector of the country. Given that the coal is one of the cheapest and accessible type of fuel, and at the same time one of the reserve fuels for the thermal and electricity sources, its share in the energy balance of the country follows to be increased, including with the purpose to provide for strategic reserves of fuel. This requirement complies with the needs to fortify the energy security of the state.

The import of liquid fuel to the Republic of Moldova is made from the Russian Federation, Ukraine and Romania. The share of residual fuel oil is considerable because it represents a reserve fuel for many energy sources from the country. As a result of shortage of finance, the economic agents are not in position to stock sufficient reserves of residual fuel oil in order to cover the need of stable operations of the enterprises from the energy sector, particularly in the winter season. Given the need to provide for the energy security of the state, at present the consumption of residual fuel oil in the energy sector is considered sufficient. Increasing capacity to use the residual fuel oil and creation of reserves for this type of oil represents one of the strategic priorities of the country.

1.2. Consumption, production and imports of energy

During the last ten years, the provision of the country with energy and fuel was marked by hard deficiencies, generally, due to application of certain tariffs that do not reflect real costs, due to providing certain exemptions and compensations without coverage, as well as due to involvement of the decision makers in economic relations between the suppliers and consumers. Ultimately, this situation led to a financial blockage and to an unprecedented financial crisis.

Thus, the Republic of Moldova is a country that depends almost totally (98%) from energy supply from abroad. Taking into account the current geopolitical conditions and their eventual evolution, the formation of a necessary framework for an efficient operation of the energy sector represents a stringent need for the state.

In this situation, the energy security can be insured by diversifying foreign suppliers of electricity supply and oil products, by developing own capacities of producing electricity, as well as by creation of strategic reserves of fuel (*Box 1.5*).

The energy sector consumes, mainly, natural gas, residual fuel oil and coal (*Table 1.3*). These fuels are used, usually, and in the industry. In the transportation sector are used big amounts of gasoline and Diesel oil, and in the housing sector – wood and agricultural residues.

Box 1.5. *Main mid-term objectives of the liquid and solid fuels supply sector*

- Diversifying the imports of liquid and solid fuels.
- Finishing the construction of the oil terminal from Giurgiuleshti and adjacent oil networks, as well as gradual consolidation of the operational capacities of this objective.
- Creation of conditions for a competitive sales market for oil products and coal.
- Working out the computerized system for registering at the border of the Republic of Moldova of imports - exports of oil products and solid fuel.

Table 1.3. *The trend of imports of the main energy sources in the period of 1990-2000, thousand t.c.e.*

Resource \ Year	1990	1991	1992	1993	1994	1995	1996	1997*	1998*	1999*	2000*
Natural gas	*4,420*	*4,408*	*4,069*	*3,563*	*3,478*	*3,426*	*3,977*	*2,373*	*2,108*	*1,508*	*1,297*
Coal	*3,608*	*3,074*	*1,982*	*1,483*	*1,134*	*1,029*	*844*	*292*	*394*	*147*	*108*
Residual fuel oil	*3,446*	*2,606*	*2,182*	*1,140*	*675*	*660*	*425*	*403*	*271*	*128*	*64*
Gasoline	*1,182*	*883*	*435*	*332*	*319*	*387*	*371*	*404*	*291*	*179*	*182*
Diesel oil	*1,737*	*1,426*	*859*	*962*	*556*	*667*	*528*	*527*	*386*	*277*	*300*
Liquefied gas	*229*	*193*	*151*	*63*	*63*	*61*	*52*	*44*	*38*	*62*	*79*
Aviation gasoline	*101*	*110*	*45*	*29*	*18*	*20*	*31*	*30*	*30*	*22*	*25*
Total	**14,723**	**12,700**	**9,723**	**7,572**	**6,243**	**6,250**	**6,228**	**4,073**	**3,518**	**2,323**	**2,055**

***** *It is indicated the import of electricity only for the territory of the right bank of the river Nistru*

The period of 1990-2000 was characterized by an economic decline, lack of financial resources for a sufficient import of electricity and continuous reduction of the fuels consumption. Thus, the consumption of natural gas in 2000 made up only 29% of the volume of gas used in 1990. If in 1990 the share of natural gas in the overall energy consumption was about 69%, in the subsequent period (1994-1998) it reduced to 50%. Essential change of this indicator took place in the time period of 1999-2000, when the share of natural gas consumption in the energy system decreased from 31% to 24% from the overall quantity supplied to the country. The reasons of these reductions are explained by the worsening of the economic situation and modification of pricing policy. This fact lead to accrual of large debts of the energy enterprises for the natural gas supplied previously, impossibility of new purchases and massive imports of electricity from the electricity systems of the neighboring countries: Ukraine and Romania. Also, there was a substantial reduction of the volume of local production of energy.

At the end of 1998 about 360 thousand flats and private houses were connected to the natural gas network. The total consumption of natural gas in 1998 amounted to about 300 mil. m^3. It is worth mentioning that in the Republic of Moldova there is a high demand of LPG – particularly in the zones where the natural gas is missing. Almost 90% of the import of liquefied serves for feeding the household consumers. At present, the LPG is used in over 80 thousand individual houses and flats.

In 1990 the solid fuel had a considerable share in the energy balance of the country. Later on, this type of fuel has considerably diminished, so that by the year of 2000 the share of coal in the structure of energy balance constituted only 5.3% of the total consumption.

In the energy sector the residual fuel oil was and continues to be, from strategic viewpoint, the reserve fuel for most energy sources in the country. The share of this fuel in the energy balance of the country in 1990 accounted for 23% of the total. In 2000 the fuel amount officially imported constituted only 3.1% of the total consumption of fuel. It is considered that the records of oil products consumed does not reflect the real picture (according to some estimates, as a result of smuggling oil products – residual fuel oil, gasoline, diesel lubricants, etc. on yearly basis are introduced illegally about 1 mil. tons).

Taking into account the need to provide for the energy security of the state and possibilities regarding the storage in the country of this type of fuel (until 115 thousand t.c.e. only at the store houses and reservoirs of the CHP-1, CHP-2, CHP-North, TP Sculeni, TP South, TP East and TP Muncesti, without taking into account the storage possibilities of the storehouses and other industrial enterprises) the share of the residual fuel oil in the energy balance of the country is supposed to be increased.

While analyzing the data of the Table 1.3 one can notice, that in the period 1990-2000 the structure of the energy balance was subjected to essential changes. Thus, if in 1990 the share of the main fuels used in the energy system (natural gas, coal and residual fuel oil) was almost identical, by 2000 the amounts of coal diminished 4.7 times, residual fuel oil – 7.5 times, and natural gas almost doubled, constituting approximately 63% of the total import of energy resources. In case of some reductions (or ceasing) supplies of gas fuel, most

Table 1.4. *The domestic production of electricity for the period of 1990-2000, mil. kWh*

Source \ Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
CHP-1	*207*	*207*	*196*	*150*	*136*	*106*	*115*	*93*	*119*	*115*	*60*
CHP-2	*1,311*	*1,106*	*1,074*	*1,020*	*880*	*794*	*960*	*1,057*	*894*	*801*	*800*
CHP-North	*121*	*100*	*102*	*85*	*87*	*80*	*100*	*96*	*84*	*51*	*20*
Sugar Factories CHPs	*176*	*164*	*146*	*129*	*84*	*112*	*134*	*114*	*92*	*73*	*80*
HEP Costeşti	*37*	*71*	*60*	*66*	*46*	*84*	*87*	*84*	*54*	*91*	*85*
Moldovan TPP	*13,569*	*11,222*	*9,468*	*8,626*	*6,836*	*4,747*	*4,560*	*3,639*	*2,974*	*2,454*	*2,334*
HEP Dubăsari	*220*	*227*	*198*	*308*	*232*	*239*	*279*	*295*	*224*	*284*	*256*
Other sources	*31*	*49*	*13*	*2*	*0*	*0*	*4*	*3*	*3*	*6*	*5*
Total on the country	**15,672**	**13,146**	**11,257**	**10,386**	**8,301**	**6,162**	**6,239**	**5,381**	**4,444**	**3,875**	**3,640**

of electricity on the right bank of the river Nistru are compelled to interrupt their operations, a fact which causes hard damages to the national economy.

In 1990, in the Republic of Moldova only 2% of the electricity was produced by the hydro-electric plants (Table 1.4.), with a installed capacity of 64 MW, and the remaining (98%) – by thermo-electrical plants, with a total installed capacity of about 2934 MW (84% of this potential used to be constituted by the installed capacity of the Moldovan thermo-electrical plant from the town of Dnestrovsk, placed on the left bank of the river Nistru).

Lack of investments for rehabilitation and extension of the available energy sources, high degree of wear and oldness of the installations and energy equipment, ongoing trend of price increase for the fuels and financial blockade of the energy enterprises caused by the non-settlement of bills by the population and economic agents, imposed the reduction of internal production potential of electricity, particularly on the right bank of the river Nistru.

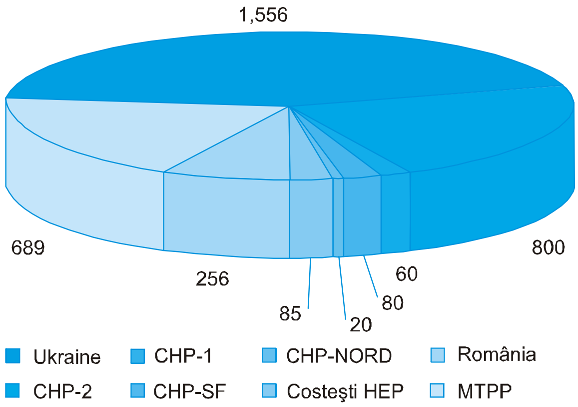

Figure 1.2. *Coverage of total consumption of electricity in 2000 (less Transnistria), mil. kWh*

In order to cover the demand of about 1100 MW, since 1995, the deficit of installed power on the right bank of the river Nistru is covered by supplies of electric energy from the Moldovan TPP and imports from Ukraine and Romania (*Tables 1.5* and *Figure 1.2*).

The average price for energy supplied by Moldovan TPP and imported one, during 1999, for instance, was US$ 31,4/MWh.

Table 1.5. *Coverage of electricity consumption (1995-2000), mil. kWh*

Indicator \ Year	1995	1996	1997	1998	1999	2000
Total consumption of electricity	*5,500*	*5,337*	*4,946*	*4,591*	*3,754*	*3,551*
Production of energy at local sources	*1,176*	*1,400*	*1,450*	*1,246*	*1,137*	*1,050*
Supplies from MTPP	*2,327*	*2,368*	*1,746*	*1,447*	*875*	*689*
Import of electricity:	*1,997*	*1,569*	*1,750*	*1,976*	*1,777*	*1,812*
– From Ukraine	*1,997*	*1,569*	*1,750*	*1,870*	*1,097*	*1,556*
– From România	–	–	–	*106*	*680*	*256*
Share of domestic sources in coverage of total consumption of electricity (right bank of the r. Nistru), %	*21.4*	*26.2*	*29.3*	*26.7*	*30.0*	*29.6*

1.3. Economical-financial analysis

The current situation of the energy sector is closely depending on the state of the national economy. During the transition period the economy of the country is in a continuous recession, being aggravated by the lack of its own energy resources. As consequence, the import thereof reaches up to 98% from the total and requires about 30-40% of GDP.

In conditions of fast raising prices for the energy consumption, enormous debts have accrued towards the suppliers of energy resources, particularly as a result of the catastrophic reduction of the possibility to pay for the consumption of energy by most consumers.

In the Republic of Moldova the problem of centralized heating is one of the most sector social issues. The respective situation is owing to the low level of collection of payments, which nowadays is so reduced, that it does not allow to reach a stable flow of cash, which may cover the prices formed for purchasing the fuel and finance the necessary investments required for increasing energy efficiency of the heating supply systems.

This situation can be resolved only by way of massive implementation of efficient energy technologies – *i.e.* a combined thermodynamic cycle and co-generation of electrical and thermal power. Rehabilitation of the thermal-energy sector facilitates, by implementing efficient energy technologies, will allow to reduce the total costs of the thermal carrier.

In the context of the mentioned above it is worth analyzing the evolution of the economical-financial position of the national energy sector during the last decade and identifying the trend occurring in this domain.

I. Fuel natural gases

All the fuel natural gases used in the Republic of Moldova is imported from abroad, and the Russian Federation is the only source of import of natural gases and liquefied ones.

The main consumer branches of natural gases have been energy sector, industrial sector and agriculture. Since 1992, there is continuous decline of consumption and imports of gas. Thus, from 1991 until 2000 the import of natural gas has reduced from 3.9 to 2.8 bil. m^3. This decrease was caused by worsening of the economic situation in the country and modification of pricing policy.

Since the break-down of the former Soviet Union, the tariff for natural gas has been constantly growing. Thus, in the period of 1991-1994 the tariff for natural gas increased several hundred times, reaching by 1994 the figure of US$ 80/1000 m^3. Given the typical annual consumption and an extremely high tariff – in situation of missing a real payment capacity – the import of natural gas within a short while generated an external debt of over USD 100 mil. (1994). Starting from 1992 and up to 1997 in the country differentiated tariffs have been applied per various categories of consumers. There used to be “crossed” subsidies – *i.e.*, some categories of beneficiaries were subsidized on behalf of the others (population and agricultural farms were subsidized on behalf of industry). The tariff applied for the industrial enterprises in the summertime of 1994 reached the maximum amount of US$ 130/1000 m^3, by approximately 60% more than the world average (*Figure 1.3*). This factor has subsequently lead industrial sector to bankruptcy. In the period of 1995-1999 the tariff for natural gases decreased considerably, mainly due to devaluation of the national currency (*Annex 1.3*) [2,3].

Starting with June 1997 for all categories of consumers were established a sole tariff – which was a pre-condition for the reformation and privatization of the energy sector. The tariffs for natural gases on 01.07.1999 are applicable at present too (January 2002). Below are provided data that characterize the evolution of the cost of the fuel gases:

In 1995:

– the cost of 1000 m^3 of natural gas was MDL 376,21 (USD 76,93) – for the electrical plants and MDL 281,47 (USD 62,55) – for the population;

– the cost of transport of natural gas, within Moldovagaz company, was MDL 36,26 (USD 7,84)/1000 m^3 transported through 100 km of gas pipeline).

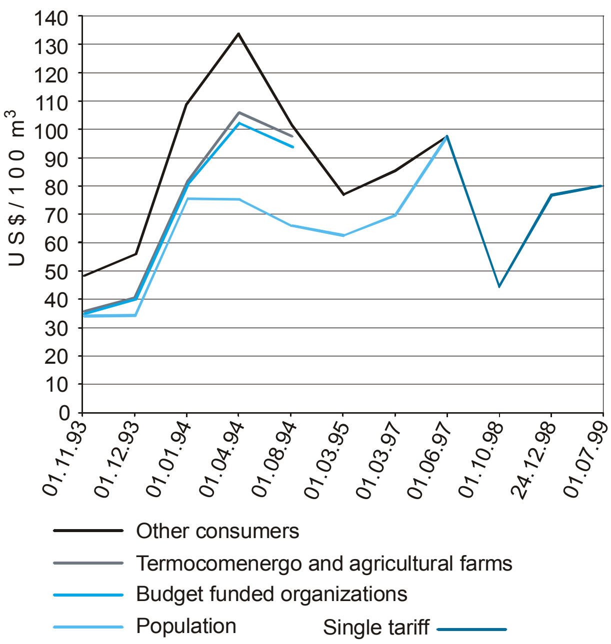

Figure 1.3. *The trend of natural gas supplied in the Republic of Moldova (1993-1999), US$ (according to the exchange rate as on the year end)*

In 2001:

- the cost of 1000 m³ of natural gas supplied to all categories of consumers was MDL 926,00 (USD 79,88);
- the cost of 1000 m³ of natural gas supplied from the transport networks was MDL 854,10 (USD 73,68);
- the cost of transport of natural gas, within Moldovagaz company, was MDL 33,08/1000 m³ (USD 2,85) transported through 100 km of gas pipeline).

It is worth mentioning that in the current tariff the cost of purchased gas constitutes about 78%, and the cost of the respective service – about 22%, which, starting from 1999, includes also the amount of USD 4/1000 m³ to cover the historical debts.

The cost of annual volumes of import of natural gases on the right bank of the river Nistru varied in the period 1994-1998 between USD 100-150 mil. (*Figure 1.4*) [2].

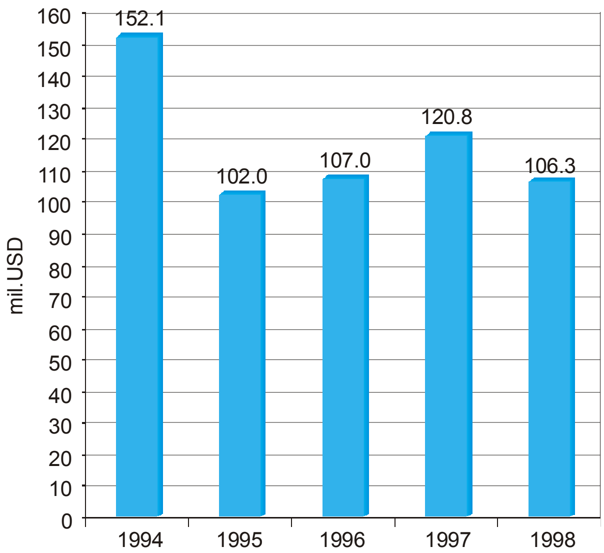

Figure 1.4. *The dynamics of the cost of the imported natural gas (1994-1998)*

The payments for the consumption have been and continue to be burdensome. The JSC Gazprom, and respectively JSC Moldovagas have made great efforts to collect the payments for gas consumption. As a result of increase, in bounces, starting from 1991, in a short while the Republic of Moldova reached a state of default. Thus, in order to settle the annual consumption of gases there were applied all possible ways:

- payments in kind (barter);
- construction of flats in Russia;
- applying for a loan from Russian Federation worth USD 39,8 mil., at an interest rate of 8% per annum (1994);
- cession of high pressure gas pipelines (USD 40,5 mil., in 1995);
- issuing securities worth USD 140 mil on the Russian financial market (1997);
- issuing by JSC Gazprom of promissory notes worth USD 90 mil. (2000).

The annual payments in cash varied between 5-10%, and during the last years the share of payments increased substantially (1999-17%, 2000-52%). Nevertheless, by the year of 2000, the total debt of the Republic of Moldova amounted to about USD 185 mil.

The debts displayed in the Table 1.6 do not include accrued penalties for timely settlement of the consumption of gas. According to the data from the JSC Gazprom, as on 01.01.2000 the total penalty accrued in the period of 1994-1999 constituted about USD 280 mil. (*Table 1.7*). At present the Republic of Moldova carries out negotiations for restructuring or even canceling these debts.

Table 1.6. *The evolution of payments and annual debts for imported natural gas (1994-2000), USD mil.*

Debts / payments \ Year	1994	1995	1996	1997	1998	1999	2000
Debts as on the beginning of the year	*7.88*	*100.14*	*129.76*	*181.62*	*100.03*	*128.24*	*198.8*
Cost of the annual consumption of gas	*152.08*	*102.03*	*107.03*	*120.76*	*106.31*	–	–
Debts at end of the year, before settlement	*159.96*	*202.17*	*240.07*	*326.03*	*223.29*	–	–
Total payments in the current year	*59.82*	*72.41*	*58.93*	*226.00*	*95.05*	–	–
% from the cost of the annual consumption	*39%*	*71%*	*55%*	*18%*	*89%*	*12.0%*	*79.0%*
Payments in cash	*0.46*	*3.62*	*13.17*	*5.13*	*4.35*	–	–
% from the cost of the annual consumption	*0.1%*	*3.5%*	*12.3%*	*4.2%*	*4.1%*	*12.0%*	*52.0%*
Debts as on the end of the year, after payment	*100.14*	*129.76*	*181.14*	*100.03*	*128.24*	*198.8*	*104.00*

Table 1.7. *Penalties for delayed payments for gas consumption, USD mil.*

Year	The right bank of the r. Nistru	Transnistria	Total
1994	*20.16*	*39.21*	**59.37**
1995	*22.70*	*17.69*	**40.39**
1996	*21.82*	*57.84*	**79.66**
1997	*26.33*	*38.20*	**64.53**
1998	*19.41*	*10.98*	**30.39**
1999	*2.30*	*1.41*	**3.72**
Total	**112.72**	**165.33**	**278.07**

It is to mention that the securities worth USD 140 mil., issued in 1997 by the Ministry of Finance of the Republic of Moldova and ceded to the JSC Gazprom for settlement of debts, were subsequently issued on the Russian financial market (1999), being finally re-deemed in an amount of USD 36 mil. only. This way the debt of the country was reduced by about USD 100 mil.

The debts of the JSC Moldovagaz exceed accounts receivable. The direct losses caused by the extra-normative consumption and gas embezzlements during 1996-1999 were considerable (*Table 1.8*).

Table 1.8. *The evolution of the extra-normative consumption in the period 1996-1999*

Year	Consumption, USD mil.	Consumption, MDL mil.
1996	*4.0*	*18.6*
1997	*1.2*	*5.6*
1998	*2.3*	*19.0*
1999	*2.1*	*24.5*
Total	**9.6**	**67.7**

Consequently, an extra-normative consumption of gases is registered. In the case of the beneficiaries without meters, the real consumption exceeds the normatives based on which tariff is calculated. In line with that, a good deal of the population uses the gas stove for inappropriate purposes – for heating the flats during the cold season of the year.

As on 01.01.2000 the losses caused by the difference of currency exchange (delay of payments), devaluation of national currency and keeping up in the country of a constant tariff in the period of 1995-1999 constituted MDL 1,1 bil. This amount comprises also the losses in amount of MDL 44 mil., caused by the fact that in 1999, the JSC Moldovagaz provided exemptions for consumption of natural gas, which were not offset by compensations in the national budget.

It is worth mentioning that almost 80% of the debts of the consumers towards JSC Moldovagaz, typically, are debts of energy sector enterprises (electrical and thermal plants).

Based on its decision No. 819 dated August 14, 2000, the Government of the Republic of Moldova took over the accounts payable worth USD 90 mil., of the JSC Moldovagaz towards Gazprom.

Thus, the debts of the Republic of Moldova towards the suppliers of natural gas JSC Gazprom have accrued due to the following reasons:

- the difference of the exchange rate caused by beneficiaries' non-payment in due time of payments for consumed gas;
- devaluation of the national currency and untimely adjustment of tariffs;
- lack of compensation sources for exemptions provided to certain categories of consumers;
- mismatch between the real consumption and normatives established for the consumers without meters;
- gas embezzlements.

II. Electricity

The evolution of the situation in the electricity sector will be considered for two time segments – before the privatization of those three distribution companies (years 1991-1999) and after their privatization (2000-2001). An important moment for benchmark for the first period is 1999, which was right before the privatization. The situation in the respective sector for this year will be set forth in details.

In the period of 1990-2000 the consumption of electricity in the country diminished considerably, almost 4.3 times (*Table 1.4 and Figure 1.5*). The reason of this phenomenon consists in the decline of the national economy and the high cost of energy.

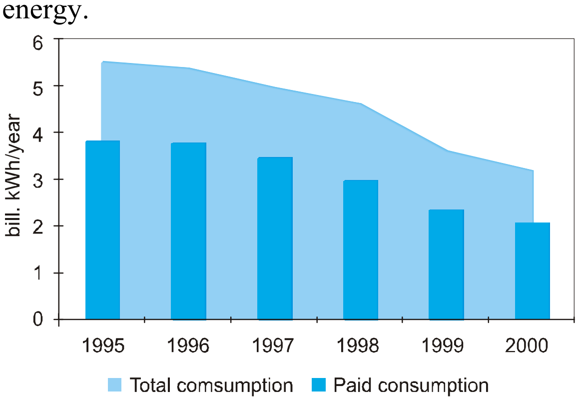

Figure 1.5. *The dynamics of the total consumption and paid consumption of electricity (1995-2000)**

The share of the paid-off electricity has been kept at a level of about 80% [2,4,5]. In 1999 in the country there were registered 1.141.363 consumers of electricity, including*:

– 1,124,923 household consumers (98.56%),

– 1,312 industrial consumers (0.11%),

– 1,744 agricultural consumers (0.15%),

– 2,018 budgetary consumers (0.18%),

– 11,366 commercial and others (1.0%).

The structure of consumption in terms of types of consumers in the respective year was as follows: population – 34.6%, agriculture – 15.3%, budget institutions – 13.5%, industry – 4.7%, commercial and others categories of consumers – 31.9%.

In 1999 – 3,539 mil. kWh entered the system, or by 18% less than in 1998. The total losses of energy constituted 1,183.4 mil. kWh or about 33% (*Table 1.9*) of the energy entered into the system, of which extra-normative losses (fraudulent consumption, non-payments) – made up 674 mil. kWh (18% of the total).

Table 1.9. *The losses of electricity in the transportation and distribution networks (1998-2000)*

Losses / Year	In the transportation networks		In the distribution networks		Total	
	mil. kWh	% of the total	mil. kWh	% of the total	mil. kWh	% of the total
1998	*194.8*	*4.5*	*1201.0*	*29.0*	*1395.8*	*32.2*
1999	*156.8*	*4.4*	*1026.6*	*30.3*	*1183.4*	*33.4*
2000	*100.3*	*4.5*	*977.2*	*31.0*	*1077.5*	*34.2*

The consumption that was paid for amounted to 2356 mil. kWh (62.8%), whereas in the previous year – 1998, this indicator was of 2,939 mil. kWh (64.2%) [5].

In 2000 in the system were supplied 3,150.6 mil. kWh. The local CHPs produced 892.3 mil. kWh, which represent about 26.5% of the total volume of energy entered the system. The total losses amounted to 1,077.5 mil. kWh, including extra-normative losses of 462.9 mil. kWh. The acquitted consumption amounted 2,073 mil. kWh.

In the period of 1993-2001 the tariff for electricity registered a growing trend (Annex 1.4), which was implied after its leveling with the costs, as well as by the devaluation of the national currency [2,3,4] (*Figure 1.6*).

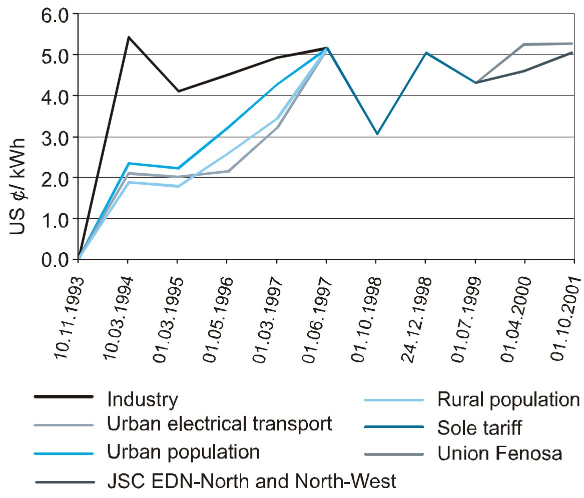

Figure 1.6. *The dynamics of the final electricity tariff (1993-2001), ¢USA/kWh at the exchange rate as on the end of the year*

Until the summertime of 1997, for all categories of consumers were established various tariffs. Since June 1997, there was applied a sole tariff which was in compliance with the real costs. However, after three years, starting from 01.04.2000, there were accepted differentiated tariffs anew: for consumers of the non-privatized EDNs (EDN-North and EDN-South-West) and the privatized ones (EN-Chişinău, EDN-Center and EDN-South). On 01.10.2001 these tariffs were up-dated. According to the National Agency for Energy Regulation, the tariffs for electricity and adjacent services as on the date of 1.01.2002 are as follows [8]:

(a)Tariff for electricity produced by the domestic power plants, bans*/kWh (cents USA, at the exchange rate as on the end of 2001):

– CHP-1 – 39.10 *bans/kWh (3.01 ¢USA/kWh).*

– CHP – 2 35.19 *bans/kWh (2.71 ¢USA/kWh).*

– CHP-North – 38.56 *bans/kWh (2.97 ¢USA/kWh).*

– HPP Costesti – 7.16 *bans/kWh (0.55 ¢USA/kWh).*

(b)Tariff for transportation and dispatching service – 2.80 bans/kWh *(0.22 ¢USA/kWh).*

(c) Tariff for consumers supplied by:

– "Union Fenosa" company – 68 bans/kWh (5.23 *¢USA/kWh*);

– Enterprises EDN-North and EDN-North-West-65 bans/kWh *(5.00 ¢USA/kWh).*

It is worth mentioning the fact that only starting from 1997, the tariffs for electricity were established at the level of real costs, the non-compliance of the tariffs with the real cost of energy having been for a long time a factor of external debt accrual.

* without Transnistria

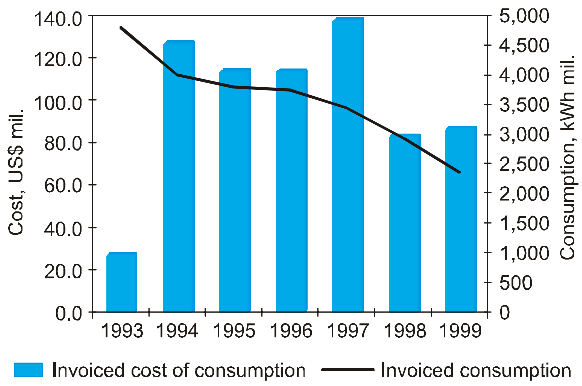

Figure 1.7. *The dynamics of the consumption and cost of the invoiced electricity (1993-1999)*

The general trend that is typical to the entire electricity sector during the last 10 years is marked by diminishing the volumes of consumption in line with diminishing the cost of the electricity (*Figure 1.7*) [2,4,5]. At the moment of reorganization of the state company "Moldenergo" (on 01.00.1997) the accounts payable of the electricity sector amounted to MDL 1487 mil, and accounts receivable – to about MDL 549.9 mil. (*Table 1.10*).

The financial losses in the sector used to amount to MDL 875 mil., of which MDL 640 mil. for the previous years and MDL 415 mil. for the first 10 months of 1997. The total financial losses until 01.11.1999 increased by MDL 657 mil. (USD 56.7 mil.), including: MDL 522 mil. (USD 45 mil.) as a result of the difference of the foreign exchange, MDL 133 mil. (USD 11.5 mil.) – due to non-compliance between the tariffs and cost level, fines and penalties.

By November 1999, when the suppliers of gases and electricity have stated their intention to cut the supply, in the energy system an extremely worrisome situation emerged. For the first time the municipality of Chisinau was disconnected from the gas pipeline and electricity for several days.

Table 1.10. *The financial position of the electricity sector (01.10.1997-01.11.1999)*

Energy sector	1997		1999	
	MDL mil.	USD mil.	MDL mil.	USD mil.
Accounts payable, including:	1487	319.1	2157.0	186.1
to electricity suppliers	362.9	77.9	958.8	82.7
suppliers of natural gas, coal and residual fuel oil	833.4	178.8	1,070.8	92.4
servicing loands	118.6	25.5	47.5	4.1
to the budget	35.0	7.5	66.6	5.7
to other creditors	–	–	13.3	1.1
Accounts receivable	549.9	118.0	1536	132.5
Deficit	937.1	201.1	621	53.6

The 1999 indicators. The energy purchased by the energy enterprises in volume of 3,539 mil. kWh cost in 1999 about MDL 1,251.3 mil. (USD 108 mil.). The payments collected from consumers for the supplied electricity amounted to MDL 1,203 mil. (USD 103.8 mil.), which represented 89% of the total planned for payment. Of this amount 29% were obtained in cash, 69% - for mutual payments and 2.0% - based on barter.

As a consequence of embezzlements of energy the sector incurred financial losses amounting to MDL 240 mil. (USD 20.7 mil.). The distribution companies, in their turn, paid to energy suppliers MDL 907 mil. (USD 78.3 mil.), which represent below 70% of the cost of purchased energy.

The 2000 indicators. On January 1, 2000 the accounts receivable for the electricity amounted for MDL 352.7 mil. (USD 30.4 mil.). The total accounts payable, including historical ones, to electricity suppliers made up at that date USD 94.7 mil. (for Ukraine – 47.1; Romania – 27.1 and Moldovan TPP – 20.2). However, the total debts towards the creditors of the electricity sector were over MDL 2,300 mil. (USD 194 mil.). As on the end of 2000 the debts of the state for electricity supplies and imports constituted USD 71 mil., of which USD 30 mil. – to Ukraine, USD 32 mil. to Romania and USD 9 mil. to Moldovan TPP [4].

Between the years of 1991-1999 the payments collected in cash did not exceed 25-29%, and in 2000 – 48%. This jump is owing first of all to the efforts of the Union Fenosa company, which excluded the barter as manner of payment for supplied electricity.

During 1991-1999 the economic-financial position of the electricity sector was characterized by:

1. Since 1990 the prices for primary energy resources and electricity have increased very much. Year by year the incapacity of the country to pay for the consumed energy has been increasing.
2. The volume of energy procurements became smaller and smaller, becouse the level of payments collection did not exceed 80%. As a result, the volume of the energy was insufficient, which implied frequent cuts of supply to consumers. By 1999 the electricity supply in the rural areas did not exceed 10 of 24 hours. The cuts were frequently uncontrolled, given that the level of supplies was determined by the

foreign suppliers. Even the solvent consumers, with foreign capital (many of them used to pay for the energy in advance), usually could not be separated from the debranched network to be supplied continuously.

3. In situation when other energy resources were missing, that were necessary for heating the housing, cooking etc., fraudulent electricity consumption amplified, the embezzlements having reached in 2000 up to 25-30%.
4. The possibilities of the state to improve the situation were very limited. In the end, the power enterprises proceeded to purchasing power on credit. This way foreign debts emerged and continued to accrue, for the imported electricity and natural gas consumed for production of electricity in the country.
5. The foreign debts of the Republic of Moldova towards the suppliers from the Ukraine and Romania for the imported electricity was about USD 100 mil.
6. Between 1994-1997 barter and mutual payments were the main ways of paying the imported resources.

The evolution of the economico-financial situation in the electricity sector in the period after the privatization of the distribution companies (2000-2001) was characterized by:

– Economic reform in the electricity sector, which in 1999 resulted in the privatization of 3 from 5 electrical distribution enterprises, by the Spanish company "Union Fenosa" (EN Chisinau, EDN Center and EDN South).
– All electricity consumers from the area served by Union Fenosa, which account for about 70% of the territory of the country, are supplied electricity round the clock.
– The accrual of foreign debt of the state, caused by the imports of electricity for the area covered by Union Fenosa was stopped.
– Barter was totally excluded as manner of payment.
– Mutual payments were ceased – which was another negative factor for the recovering of the national economy.
– All the taxes to the state, which amount for about MDL 75 mil. per year (USD 3.5-5.5 mil.) are settled on monthly basis.

III. Thermal power

The economical-financial evolution of the thermal-energy sector in the period of 1990-2000, was characterized by a reduction of thermal energy production and tariff instability (Table 1.11, Figure 1.8) [4,7]. In the period 1993-1994 the price for centralized heating in the Republic of Moldova increased a lot, from MDL 9.29/Gcal *(USD 2.55/Gcal)*, in January 1993, to MDL 301/Gcal *(USD 70.49/Gcal)* in March 1994 [2]. Later on, the price for centralized heating registered a downsizing trend, up to MDL 300/Gcal *(USD 24.22/Gcal)* in December 2000 (*Annex 1.5*), caused by the devaluation of the national currency and adjusting the tariff to the level of the real production costs.

Table 1.11. *The thermal power production and consumption (1990-2000), from 1995-without Transnistria), thous. Gcal*

Year / Indices	1990	1995	1996	1997	1998	2000
Volume of thermal energy produced	*22,775*	*7,097*	*7,077*	*6,590*	*6,120*	*3,057*
Internal consumption of thermal energy	*20,983*	*6,126*	*6,027*	*5,552*	*5,173*	*2,673*
Losses of thermal energy	*1,214*	*971*	*1,050*	*1,038*	*947*	*383*
Other distribution	*16*	*0*	*0*	*0*	*0*	*1*

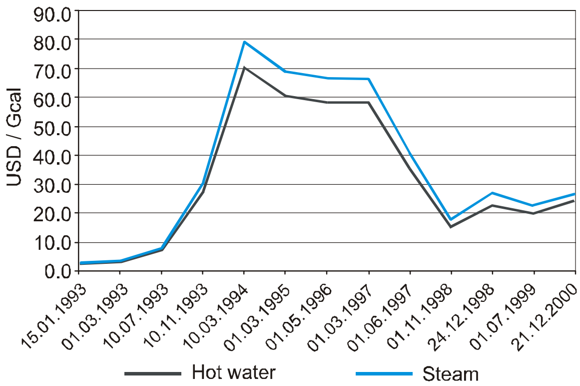

Figure 1.8. *The trend of the tariff for thermal energy (1993-2000)*

The cost of the thermal power supplied by CHPs, as established by the National Agency for Energy Regulation (NAER) in 2001, valid until nowadays, is displayed in the Table 1.12.

Table 1.12. *The cost of thermal energy supplied by the domestic CHPs*

Cost / Sources	MDL / Gcal	USD / Gcal
CHP-1	*142.08*	*11.01*
CHP-2	*134.17*	*10.40*
CHP-North	*299.00*	*23.18*

Since 01.01.2000 the responsibility for establishing the final tariff for thermal energy was commissioned from NAER to the local governments. The Table 1.13. displays the trend of the accounts receivable and payable of the companies “Termocom” and “Termocomenergo” for the period 1995-2000[4,6].

Table 1.13. *The trend of accounts receivable and payable, in USD mil. (according to the exchange rate as on the end of the year)*

Company \ Year	1995	1996	1997	1998	1999	2000
	Accounts payable					
JSC Termocom	*7.6*	*20.4*	*23.2*	*35.1*	*40.9*	*71.7*
RPA Termocomenergo*	*36.7*	*29.0*	*37.8*	*19.6*	*13.2*	*14.4*
Total	**44.2**	**49.5**	**60.9**	**54.7**	**54.1**	**86.1**
	Accounts receivable					
JSC Termocom	*25.1*	*17.8*	*21.5*	*20.7*	*22.5*	*34.2*
RPA Termocomenergo*	*28.2*	*18.1*	*18.2*	*11.4*	*9.1*	*10.7*
Total	**53.3**	**35.9**	**39.7**	**32.1**	**31.7**	**44.9**

* On July 1st 2000 the company Termocomenergo was liquidated.

In the study period (1993-2000), the solvency considerable decreased of the beneficiaries of centralized heating, a fact that triggered an essential increase of the number of unsettled invoices (for instance, in 2000 the lowest level of payments collection was registered in Chişinău, Bălți and Ungheni – about 25%, whereas in Soroca, Orhei and Floreşti this indicator was much higher – almost 50%). As a result, in the thermo-energy sector were available less money for purchasing fuel, and respectively, production volumes diminished.

It is worth mentioning that the Republican Production Association “Termocomenergo”, being responsible for supplying the republic with thermal power (except for Chişinău, where JSC Termocom operates) was liquidated on 01.07.2000, and respective infrastructure was transferred to the local governments.

1.4. Current technologies and energy efficiency

Technological process at CHPs is based on the classical cycle of steam turbines. At the domestic CHPs are used steam and hot water boilers of Russian production made at the Barnaul, Belgorod and Taganrog factories during 1951-1995.

According to the specific fuel consumption level, technologies used in the Republic of Moldova are not so efficient as the similar world ones (e.g., the nominal efficiency of the local CHPs is twice less than the modern installations). Additionally, as a result of the energy consumption reduction in the last years, the functioning regimes of the energy production enterprises, especially of CHPs, in the Republic of Moldova are far from the nominal ones. Respectively, their real efficiency is much lower than the nominal one.

In the last ten years, the domestic electricity production reduced about 4.3 times, and the heating energy production reduced more than 7.4 times. First of all, low sails of heating and electricity caused the substantial reduction of the electricity and heat production. They depend directly by the population solvency and payments for delivered energy. Because the last decade was characterized by a continuous growth of unpaid bills, less money were available for fuel purchasing, thus reducing the production volume.

The total domestic installed capacity of electricity production plants is about 2950 MW, and the available one – only about 1300 MW. With small exception, all electricity and heat production sources in the country are 20 years old, and some of them are more than 30 or even 45 years old.

1.4.1. Current technologies and energy efficiency at the energy production sources

I. Moldovan Thermal Power Plant (TPP)

Current technologies. In the Republic of Moldova there is only one Thermal Power Plant, located in Dnestrovsk – Transnistrian region. This plant has an installed capacity of 2520 MW capacity, with an actual available power of 950 MW. Moldovan TPP is equipped with ten condensing energy units each 200-210 MW, and two energy units functioning according a mix gas-steam cycle, with an installed capacity of 245 MW each. (*Annex 1.6*).

Technological processes used at Moldovan TPP are based on the classical cycle of steam condensing turbines, that means organic fuel burning for electricity production, and heat production representing only a secondary process (*Box 1.6*).

Energetic efficiency. According to the specific consumption of fuel, energy units of the MTPP of 200-210 MW each are less efficient than the same world installations (*Table 1.14*).

Table 1.14. *Specific consumption of fuel at the condensing thermal power plants*

Installed power of the condensing energy units	Specific consumption of fuel, g.c.e./kWh
1. Russian Federation:	
200 MW	338-350
300 MW	336-346
500 MW	336-344
800 MW	312-322
1,200 MW	312-314
2. Germany (Siemens):	
450 MW	254
3. Republic of Moldova:	
200 MW	380-420

Comparative features of the gas-steam turbines installations (GSTI) with the installed power of 245 MW each, being composed of steam turbines K-210-130 LMZ, gas turbine GTG 35-770 HTZ, steam boiler TME-206 and condensing install-lations of 210 MW installed at Moldovan TPP, are listed below (*Table 1.15*).

Table 1.15. *Comparative feature of some parameters of GSTI and condensing units at the Moldovan TPP*

Technical parameters	Measures units	Installation type	
		Gas-steam	Condensing
Capacity:			
- steam part	MW	210	210
- gas part	MW	35	–
- installation, gross	MW	245	210
Fuel consumption:			
- in gas turbine installa-tions (Q_i^r=39000 kJ/kg)	kg/s	3.33	–
- in steam boiler (Q_i^r=39000 kJ/kg)	kg/s	11.75	14.03
Fuel consumption for a power production unit	g.c.e./ kWh	320-370	380-420

The table shows that using the mixed GSTI cycle, in comparison with the usual condensing units, it ensures an economy of about 20% of the total consumption for the unit group and can be easily put into operation in the top hours. At Moldovan TPP the used gas-steam installation (turbine GTG-35-770 HTZ) has an efficiency of 24.8% at an air pressure up to 0.8 MPa and the gas temperature at the turbine entrance of 770 °C. These parameters are less inferior than those of the modern gas turbines with an efficiency up to 39% at an air pressure up to 3.0 MPa and the gas temperature at the turbine entrance of 1,300 °C.

Box 1.6. *Moldovan TPP – used technologies*

At the Moldovan TPP have been used the following fuels: natural gas, residual fuel oil, coal and easy liquid fuel for gas turbines. Coal used to be burned by flame in the combustion chambers. For this purpose it was grind in special mills and in the form of dust used to be transported through the pipes by a hot air flow with a temperature of 400°C, being introduced in the combustion chamber through the burner. Coal used to be burned at the temperature of about 2,000°C. The liquid fuel easy for gas turbines is injected in the combustion chambers without any preliminary heating, and the residual fuel oil used to be heated preliminary up to 120-140°C. The burning process of these fuels in the combustion chambers of the boilers is occurring at 1800-2200°C. The burning gases are cooled by the heat exchange surfaces of the boiler, giving the heat to the water, steam and air. The gases cooled to the temperature of 110-180°C usually are discharged through the flue. During the process of coal burning, about 20% of the ashes remains in the combustion chamber, forming the slag that, having 1200-1400°C in the liquid form, flows in a water basin where it cools and gets solid. The rest of the ash is used by the burning gases and caught in the wet scrubber dust catcher, located after the heat exchange surfaces of the boiler. The efficiency of the dust catcher consists of 95%. About 3-4% of the ash remains in gases and is discharged into the atmosphere through the flue. The caught ash is washed with water and together with the slag, beforehand, is transported by water through the pipes to the ash pit.

The main elements of the steam turbine installation cycle are: boiler, turbine, condensers, supply and condensation pumps. In order to avoid corrosion of the boiler surfaces, the supply water is air cleaned, and after that is directed into the boiler with a pressure of 16 MPa and a temperature of 230-280°C. Here the water is heated up to the boiling temperature and is transformed into steam. The steam is overheated up to the temperature of 565°C and is directed to the high pressure cylinder of the boiler, where it expands, performing a job up to 2.5 MPa, after which it returns to the intermediate over-heater of the boiler, where it is overheated again up to the initial temperature. When it returns to the turbine, passing through medium and low pressure cylinders, the steam expands to the pressure of 3-5kPa. The used steam is directed to the condensers, where it is condensed, being cool by the water from the circulation system of the station. The condensed is pumped to the gas cleaner up. To increase the thermal efficiency of the cycle, the condensed and supply water is heated in 7 regenerative pre-heaters with the steam from the fixed plugs of the turbine. The additional water for substituting the losses at the central is prepared in the water treatment division. Natural water is strained, filtered against mechanical impurities, cleaned of the oil substances and Si and Fe ions. Na and H ions substitute Ca and Mg ions of hard acids in the negative ion filters. Acid radicals of the acids are caught in the positive ion filters. Electric generator stays on the same shaft with the turbine. It produces electricity with a voltage of 15 kV, which raises up to 110, 330 or 400 kV by the individual transformers of the energy units and is delivered into the electrical power system.

After condensation, the circulation water is directed into Cuciurgan lagoon, several kilometers from the power plant location, and cools by evaporating from the lagoon surface. The heat given off in the lagoon consists of about 50% of the fuel energy consumed. The mix cycle groups have the same steam part as simple cycle generating units with steam condensing turbines. Moreover, they are attached by an installation of gas turbine with a capacity of 35 MW (Type GTG-35), that eliminates the used burning gases with a temperature of 400°C and oxygen content of 16.6%, in the boiler's combustion chamber, where the additional fuel is introduced, necessary to ensure the full productivity of the boiler. The gas turbine installation consists of the following: air compressor, combustion chamber and the gas turbine itself. The atmospheric air compressed in the compressor up to the pressure of 0.8 MPa is directed in the combustion chamber chamber, where the fuel is introduced. The burning gases with the temperature of 770°C enter the turbine and, expanding up to the atmospheric pressure and temperature of 400°C, rotate the shaft. Besides the turbine, the air compressor and the electric generator itself with a voltage of 10 kV are situated on the shaft.

The efficiency of MTPP considerably decreased in the last period. If the average specific fuel consumption in the years 1970-1980 was under 340 g.c.e./kWh, than during 1991-1996 this index varied between 370-430 g.c.e./kWh. Nevertheless, together with the preservation of the condensing energy units consuming coal and burning gas and usage of the two energy units that function according to a mix gas-steam cycle consuming natural gases, the specific fuel consumption reduced in the last years varying between 370-385 g.c.e./kWh (*Table 1.16*).

Electricity production of electricity at MTPP during 1990-2000 reduced by almost 6 times. Because thermal energy is a secondary product for the condensing thermal power plant and need no supplementary fuel consumption, production of this energy remained at the same level in this period, a fact determined by the demand of the Dnestrovsk town.

II. CHPs

CHPs cogenerate electrical and thermal energy, the last being partially a waste resulted at electricity production. This fact considerably increases the efficiency of fuel use.

Current technologies. Technological process at the country CHPs is based on the classical cycle of the steam turbines (*Box 1.7*) and consists of two separate ways:

- fuel and burning air-gas way;
- water-steam way.

The following installations are used at the country CHPs: steam boilers made at the factories from Barnaul and Taganrog during 1951-1993, type TC-35GM-50, TGM-96B, DKBR-6.5/13, BKZ-75/39-GM and BKZ-120-100GM; hot water boilers made during 1971-1988 at the factories from Barnaul and Belgorod, type PTVM-100 and KVGM-180, and steam turbines made at the factories from Kaluga, Breansk and Saint-Petersburg during 1957-1995, type R-12-35/5M, PT-12/15-35/10M, PT-80/100-130/13, R-6-90-37, R-27-90-1.2 and R-10-35-1.2.

Box 1.7. *Brief description of the technologies used at CHPs*

The fuels used at all domestic CHPs are natural gas and residual fuel oil. Natural gas is delivered to Chişinău and Bălţi cities through main pipes of 75 bars, and the gas distribution system is provided for 12 and 3 bar, CHPs being connected to the distribution system of 3 bar by 75-mm pipes. Gas from the pipes comes to the pressure reducing stations and is counted, filtered and reduced to the 0.5 bar pressure. Having no tanks, the gas cannot be stored at the plants and it is impossible to make reserves.

Residual fuel oil is delivered to the plants by railroad and it is stored in tanks. For example, storage capacity at each CHP-1 and CHP-2 Chişinău represents about 1,600 mł, and at CHP-North from Bălţi – about 2,000 m^3, and these quantities are sufficient to function one month at a 30-40% productivity. Residual fuel oil is heated up to the temperature of 50-75°C, when transporting through the pipes. After that, it is heated up to 100-140°C to be pulverized in the boilers' combustion chambers. The heating process foresees the steam use, which increases the residual fuel oil humidity up to 3-5%, later being strained and evacuated. According to the technological process, it is foreseen to clean the water from the oil and to introduce it into the technological cycle. But, in practice, the water is poured out into the sewerage.

The fuel burns in the boilers' combustion chambers, where the fuel and oxidant – usually air, heated up to 150-300°C, are introduced through the burners. The burning process in the boilers' combustion chambers of the CHP is occurring at 1,700-2,000°C. The burning gases are cooled in the heat exchange surfaces of the boiler, giving the heat to the water, steam and air. The gases cooled to the temperature of 138-245°C are discharged through the flue. In the process of oil burning a certain quantity of ash (about 50 mg/ mł) is eliminated into the atmosphere in the form of dust. Boilers for gas and liquid fuel currently used are not equipped with evacuated gas-cleaning installations.

Electrical energy generating process consists of water heating in the boiler up to the boiling temperature and its transformation into steam. After overheating up to 400-560°C, the steam is directed to the turbine, where the thermal energy is transformed into mechanical work and after that, through an electric generator, the mechanical work is converted into electricity.

At the CHPs of the sugar-beet factories and CHP-1 Chişinău, the steam is expanded to the pressure of 0.7-4 bar (temperature of 90-140°C), after that it is delivered to the consumers. High pressure steam (7-13 bar) for technological consumption is obtained through adjustable plugs of the intermediate steps of the turbines. At CHP-2 Chişinău, CHP-North Bălţi and one turbine of CHP-1 the steam is expanded to a pressure of about 5 kPa, and after that is directed to the condenser. In the condenser it is transformed into liquid. The evaporated water in the cooling tower is almost equal to the steam debit through the condenser.

The condensed obtained in the condenser and network heating is pumped into the gas cleaning installation to be cleaned from the gases that may produce corrosion of boiler surfaces. In the gas cleaning installation is introduced the additional water to substitute the losses of water and steam in the cycle, and also the steam consumed in the industrial technological processes without condensed returning. From the gas cleaning installation the water gets into the supply pump and is directed into the boiler.

In the network heating the water is heated up to 105-115°C, which corresponds to the exterior air temperature of 5°C. To heat the water to higher temperatures than the shown ones (top tasks), hot water boilers (HWB) are available at the municipal CHP with a high productivity (50-200 MW).

Table 1.16. *Dynamics of the energy efficiency and electric and thermal energy production at the Moldovan TPP during 1990-2000*

Indexes / Year	Available power, MW	Electrical energy, mil. kWh	Thermal energy, thou Gcal	Total fuel consumption, TJ	Specific consumption, g.c.e./kWh
1990	*2,445*	*13,569.0*	*160.0*	*130,878.3*	*329.2*
1991	*2,428*	*11,222.0*	*190.0*	*116,095.1*	*353.1*
1992	*1,990*	*9,468.0*	*160.0*	*103,888.4*	*374.5*
1993	*1,770*	*8,626.0*	*154.0*	*67,995.1*	*369.0*
1994	*1,500*	*6,835.7*	*165.5*	*75,215.5*	*375.5*
1995	*1,160*	*4,746.9*	*181.4*	*54,473.7*	*391.7*
1996	*1,000*	*4,560.4*	*190.5*	*57,446.8*	*429.9*
1997	*1,000*	*3,280.3*	*185.2*	*43,003.2*	*403.3*
1998	*950*	*2,525.0*	*140.7*	*33,342.6*	*382.6*
1999	*950*	*2,454.0*	*150.2*	*27,512.7*	*382.0*
2000	*950*	*2,290.0*	*156.8*	*25,088.1*	*373.9*

The total capacity of the country CHPs represents 415.5 MW, 97.5 MW of which belong to the sugar factories' plants. These plants usually function only during the sugar-beet processing season (3-4 months per year), consuming for self use about 60-90% of electricity produced.

We underline that, with small exceptions, all heating electric plants from the country are more than 20 years old, and some of the are around 30 and 40 years old (*Table 1.17*).

Energetic efficiency. Heating index represents the ratio between the installed thermal capacity of the installations that function in the co-generation cycle and the total thermal capacity (co-generation plus hot water boilers). This index is quite small at the CHP-1, CHP-North and CHPs of the sugar factories: for example, in 1990 the total thermal capacity for the country represented 16.8 GW, and the thermal capacity of the adjustable plugs and counter-pressure turbines from the public CHPs and CHPs of the sugar factories was only 1.7 GW. Global efficiency (ratio between the sum of the electric and thermal energy and the energy of the consumed fuel) at the CHPs with a nominal functioning regime (at the designed parameters of the equipment) is quite high, of 80-90%. Because the electric efficiency at the CHPs from the Republic of Moldova is under 20% (the efficiency at only CHP-2 is about 30%), it is considered that efficiency of these technologies is reduced.

It is shown below the dynamics of electric and thermal energy production at the municipal and sugar factories CHPs during 1990-2000 (*Table 1.18*). electricity production reduced during 1990-2000 by 2-4 times, and the thermal energy – by 3-10 times. The strong diminution of electricity

Table 1.17. *Features of the heating electric plants*

Power station	Installed electrical capacity, MW	Installed thermal capacity, MW		Heating index	Date of commissioning	Fuel
		total	HWB			
CHP-1 Chişinău	*46*	*455*	*230*	*0.24*	*1951-1974*	*gas, residual fuel oil*
CHP-2 Chişinău	*240*	*1,425*	*765*	*0.36*	*1976-1980*	*gas, residual fuel oil*
CHP-North Bălți	*28*	*610*	*465*	*0.16*	*1956-1970*	*gas, residual fuel oil*
SF "Alexandreni" JSC	*12*	*350*	–	*0.03*	*1963-1964*	*residual fuel oil*
"North-Zahar" JSC, Briceni	*18*	*235*	–	*0.08*	*1985*	*residual fuel oil*
SF "Cupcini-Cristal" JSC	*12*	*93*	–	*0.13*	*1961-1981*	*gas, residual fuel oil*
SF "Donduşeni" JSC	*10*	*90*	–	*0.11*	*1957-1991*	*gas, residual fuel oil*
SF "Drochia-Zahar" JSC	*10*	*62*	–	*0.16*	*1956-1980*	*gas, residual fuel oil*
SF "F.Z. Făleşti" JSC	*7.5*	*55*	–	*0.14*	*1968-1981*	*gas, residual fuel oil*
SF "Frunze" JSC, Gârbova	*12*	*100*	–	*0.12*	*1969-1981*	*gas, residual fuel oil*
SF "Trecontact-Zahar" JSC, Ghindeşti	*6*	*50*	–	*0.12*	*1982*	*residual fuel oil*
SF "Glodeni-Zahar" JSC	*10*	*75*	–	*0.13*	*1977*	*gas, residual fuel oil*

Table 1.18. *Dynamics of electric and thermal energy production at CHPs*

Year	CHP - 1		CHP - 2		CHP - North		CHP - SF
	Electrical energy, GWh	Thermal energy, TJ	Electrical energy, GWh	Thermal energy, TJ	Electrical energy, GWh	Thermal energy, TJ	Electrical energy, GWh
1990	*207.5*	*2,090.0*	*1,150.0*	*2,544.7*	*121.0*	*1,360.0*	*176.0*
1991	*207.0*	*2,234.0*	*951.4*	*2,775.8*	*100.0*	*1,450.0*	*164.0*
1992	*196.3*	*1,859.0*	*923.4*	*2,577.6*	*102.0*	*1,144.0*	*146.0*
1993	*150.2*	*1,378.0*	*883.4*	*2,021.6*	*75.0*	*834.0*	*129.0*
1994	*136.5*	*1,116.0*	*751.2*	*1,631.6*	*87.0*	*625.0*	*87.0*
1995	*106.5*	*968.5*	*670.9*	*1,518.2*	*81.0*	*596.0*	*112.0*
1996	*114.6*	*858.6*	*838.8*	*1,515.0*	*100.0*	*642.0*	*134.0*
1997	*93.2*	*882.1*	*896.2*	*1,524.6*	*96.0*	*500.0*	*114.0*
1998	*138.6*	*1,045.9*	*723.3*	*1,296.0*	*75.0*	*416.0*	*92.0*
1999	*115.0*	*584.5*	*672.0*	*1,286.5*	*51.0*	*247.0*	*73.0*
2000	*100.8*	*502.8*	*559.4*	*947.0*	*27.0*	*126.0*	*57.0*

production at CHPs can be explained, first of all, by low sails of heat that depend directly on population solvability and payments for the delivered heat, which resulted in a continuos increase of the unpaid bills. As a result, less money was available to purchase fuel, and, consequently, the production volume decreased.

Dynamics of the energy efficiency of the country CHPs is shown below (*Table 1.19*). Global efficiency characterize the efficiency of electric and thermal energy production, while electric efficiency – only the efficiency of electricity production.

Despite the fact that the global efficiency of CHP-1 and CHP-North is quite high, their electric efficiency is very low, and this fact shown that they function in a close regime of the thermal plants (*Box 1.8*).

Global efficiency at CHP-2 is smaller, but the electric efficiency is 2-3 times higher due to the higher parameters of the steam at the entrance of the turbine, type PT-80/100-130/3, (pressure 13 MPa and temperature 540 ^{0}C instead of 3.5 MPa and 410 ^{0}C of the turbines type R-12-35/3M, PT-12/15-35/10M, R-6-90-37, R-27-90-1.2 and PR-10-35-1.2 from CHP-1 and CHP-North), and due to the higher heating index. In the last 4-5 years the global efficiency at CHP-2 considerably reduced, thermal energy (*Table 1.19*). Its functioning capacity was also limited by irregular fuel deliveries, as a result of large debts to the suppliers, especially to "Moldovagaz" JSC (*Box 1.9*). In the summer time, use of available capacity of thermal energy production of the plant is limited by the condenser's dimensions (designed for a steam productivity of maximum 220 t/h with an optimal temperature of cooling water of 20 ^{0}C). Technological steam is delivered the whole year, but maximum available power depends on hot water delivery (at a central heating load of 5,000 mi/h the maximum capacity is up to 160 MW, and without hot water, only 80 MW).

Box 1.8. *Brief technological features of thermo-electric plants CHP-1 from Chişinău and CHP-North from the town of Bălți municipalities*

One of the main tasks of CHP-1 is the central heating and delivery of steam to the industrial enterprise from the region and the plant cannot operate producing only electricity. The longest period of functioning during a year at CHP-1 was of 8,040 hours, with a brake of 720 hours for summer period (1991). It should be mentioned that in the last years the functioning period was shorten, and efficiency decrease was considerable.

Specialists from CHP-1 explain the efficiency losses by the fact that the delivery temperature of water is lower than the designed one, steam pressure is 3.28 MPa instead of 3.5 MPa. Also, the real counter pressure of the oldest turbine, made in 1957, type PR-10-35-1.2, is higher than the designed one. It should be mentioned that, from geographical point of view, the plant is very well placed. But residual fuel losses in consumers' systems and lack of stimulus to diminish them affected a lot the productivity of CHP-1 in the last years [1].

At its turn, CHP-North can function in a central heating regime with a maximum charge of electrical load of about 20 MWe at the thermal duty of 160 Gcal/h. Production is limited by the reduced demand for heating and technological steam. In summer time the electrical load at CHP-North is on average about 7-8 MWe at a thermal duty of 90 Gcal/h. In the latest years, the capacity of the station was reduced as a result of small demand for steam and hot water, especially in summer time, as well as a result of irregular fuel delivery. Thus, in the last seven years, the thermal load at CHP-North reduced more than 50%, and this fact led to the decrease of the electricity production. For example, for the year 2000, production of electricity at CHP-North reduced by 64%, and sales of electricity – by 70%, in comparison with the year 1998.

Currently, there are registered different values of the available electric capacity at this plant, which varies from 20.4 MWe to 28.4 MWe, because of the counter-pressure of the forth turbine, type R-12-35/5M (5 kg/cmł to 8 kg/cmł). This difference between the installed and available capacities is due to the decrease of the productivity of hot water boiler, type PTVM-100, caused by ventilators deterioration and increase of false air infiltration into the combustion chamber [1].

Specific fuel consumption, which represents the main characteristic of energy efficiency at separate production, and is an appropriate index to be used at mixed production, because of methodology. Until recently, physical method of fuel distribution between electric and thermal parts was used at the country CHPs, when co-generation advantageous

Table 1.19. *The operation efficiency of CHPs*

Year	CHP - 1		CHP - 2		CHP - North	
	Total efficiency	Electric efficiency	Total efficiency	Electric efficiency	Total efficiency	Electric efficiency
1990	*0.84*	*0.07*	*0.76*	*0.21*	*0.87*	*0.06*
1991	*0.77*	*0.06*	*0.79*	*0.18*	*0.88*	*0.05*
1992	*0.77*	*0.06*	*0.79*	*0.19*	*0.88*	*0.06*
1993	*0.89*	*0.08*	*0.75*	*0.21*	*0.89*	*0.10*
1994	*0.77*	*0.07*	*0.76*	*0.21*	*0.85*	*0.09*
1995	*0.80*	*0.07*	*0.78*	*0.21*	*0.86*	*0.09*
1996	*0.76*	*0.08*	*0.69*	*0.20*	*0.80*	*0.10*
1997	*0.89*	*0.07*	*0.65*	*0.22*	*0.77*	*0.11*
1998	*0.87*	*0.09*	*0.70*	*0.20*	*0.77*	*0.10*
1999	*0.85*	*0.12*	*0.69*	*0.21*	*0.71*	*0.11*
2000	*0.88*	*0.13*	*0.66*	*0.20*	*0.72*	*0.10*

Box 1.9. *Brief technological features of thermo-electric plants CHP-2 from Chişinău municipality*

During 1996-2000 about 40% of energy at CHP-2 was obtained under condensation regime. For example, in 1999 only 490 GWh of the total 800GWh were produced through co-generation. Heat emissions discharged into the atmosphere through cooling towers represent direct losses of energy. Annual amount of this wastes are of 59 mil. mł of natural gases, representing an energy value of 4.7 mil. USD. CHP-2 registers considerable economic losses, producing energy under condensation regime at present prices of natural gas and volume of electricity sold. This was one of the causes that this pwer plant stopped in the autumn of 2000.

Another problem of CHP-2 represents the increased consumption of water, about 56 t for 1 Gcal delivered, e.g. 2.7 times more than the designed quantity. This fact is due to the central system functioning with a high debit and small difference - 18şC – of water temperature between turn and return lines. Steam sails represent 10-20 t/h, the CHP having a capacity of 60t/h. At CHP-2 the steam is not recycled because there is no return of condensed [1].

were attributed only to electricity (the heat, restituted from the electricity production process, is used as supply in co-generation process, and this fact allows to save 20-40% of fuel, in comparison with the same electric and thermal energy produced in the separate way) [10]. Thus, the specific fuel consumption for producing the electricity was twice less than at the condensing plants. Currently, the so-called economic method is used, where the advantageous of co-generation are distributed between both energy forms (see data on specific fuel consumption as for the year 2000), (*Table 1.20*)[11,12]).

Under these conditions, a more objective evaluation of the co-generation advantage can be obtained calculating the energy efficiency when the electric efficiency of the plant is 35%, typical for the classical condensing plants.

Real efficiency of the co-generation process can be characterized with maximum correctness only using the principle of estimation of fuel saving at CHPs and comparing total production of the same amount of energy with their separate production of electricity and heat (electricity production at a classical condensing station with an electric efficiency of 35%, thermal energy production with 90% efficiency) (*Table 1.21*)

To compare, in the table is shown the energy efficiency of a modern CHP. In the improved option as a support is used: for electricity production – installation of 375 MW with a mixed gas-steam cycle, made by Siemens (output 57.8%), and for thermal energy production – modern autonomous boilers (output 95%).

As the table shows, Moldovan GHPs were designed with a quite big efficiency, having a fuel

Table 1.20. Specific *fuel consumption for energy production at the Chişinău CHPs*

Anul	CHP - 1			CHP - 2		
	Specific consumption, plant's data		Specific consumption at an electric efficiency of 35%	Specific consumption, plant's data		Specific consumption at an electric efficiency of 35%
	kg.c.e. / kWh	kg.c.e./GJ	kg.c.e./GJ	kg.c.e. / kWh	kg.c.e./GJ	kg.c.e./GJ
1990	*0.155*	*37.6*	*30.0*	*0.207*	*39.7*	*19.2*
1995	*0.160*	*38.1*	*30.3*	*0.192*	*40.4*	*16.9*
2000	*0.358*	*28.2*	*19.4*	*0.331*	*31.5*	*21.3*

Table 1.21. *Energy efficiency, fuel consumption and savings at domestic CHPs in comparison with a modern CHP Berlin Mitte*

CHP and its functioning regime		Energy produced from $1 m^3$ of gas		Fuel saving in comparison with separate production, %	
		electricity, kWh	thermal energy, MJ	Classical option	Improved option
CHP - 1	nominal	*2.23*	*21.8*	*40.9*	*10.0*
	year 1990	*0.61*	*27.9*	*11.3*	*-1.0*
	year 2000	*1.21*	*25.3*	*21.1*	*2.0*
CHP - 2	nominal	*2.97*	*16.1*	*44.7*	*5.9*
	year 1990	*1.98*	*18.4*	*21.9*	*-5.3*
	year 2000	*2.1*	*14.9*	*14.0*	*-14.1*
CHP - North	nominal	*2.04*	*22.4*	*37.0*	*8.4*
	year 1990	*0.58*	*27.2*	*8.1*	*-3.7*
	year 2000	*1.04*	*20.2*	*-1.0*	*-17.2*
CHP Berlin Mitte	nominal	*4.39*	*14.0*	*81.4*	*25.7*

saving of 40% in comparison with separate production. If functioning in a nominal regime they would be efficient even in comparison with modern installations of separate production. But because the functioning regimes of CHPs from the Republic of Moldova are far from the nominal ones, their real efficiency is more inferior to the nominal one, and in comparison with the modern installations is negative (modern CHPs have a double efficiency).

III. Thermal Plants (TP)

Current technologies. Thermal plants of different types produce thermal bearer – hot water and steam, - for all sectors of the national economy, including for the residential sector. The current structure of thermo-energy sector in the Republic of Moldova is as follows (*Table 1.22*):

1. Large thermal plants – from 50 to 200 Gcal/h (58-240 MW) have a share of 0.4% of all, and volume of deliveries of thermal bearer represents about 24% of all.
2. Medium size thermal plants - from 20 to 50 Gcal/h (23-58 MW) have a share of 1.2% of all, and volume of deliveries of thermal bearer represents about 16% of the total.
3. Small size thermal plants - up to 20 Gcal/h (up to 23 MW) have a share of 98% of all, and volume of deliveries of thermal bearer represents about 60%.

For all Moldovan thermal plants coal and residual fuel oil are the main fuels in non-gas-supplied areas, and in gas-supplied areas these types of fuel serve as reserve ones. Because TPs that use residual fuel oil need steam, they are equipped, besides the hot water boiler, with steam boilers, DKVR or DE type, for heating and pulverization of residual fuel oil (*Annex 1.7*).

The way "fuel and air – burning gas" is not too different from the way of CHPs, except the fact that preheating of air is not used. Most TPs boilers are not equipped with steam over-heaters; thus, boiler produce saturated steam. Working pressure of DKVR and DE boilers represents 14 bar; so, the steam temperature is of 194şC. The steam is delivered to technological consumers (pressure of 10-13 bar) directly from the collecting bar of the thermal plants boilers.

Energetic efficiency. In the Republic of Moldova, thermal plants of large (50-200 Gcal/h) and medium (20-50 Gcal/h) productivity are used in large and local central heating systems from country former regional centers – 39 towns, as well as at large and medium size industrial enterprises. Small thermal plants (0.6-20 Gcal/h) serve the local heating systems, small enterprises, institutions, administrative and commercial and residential buildings.

The large thermal plants of Chisinau (TP South, TP East, TP West and TP Muncesti) are part of "Termocom" JSC (*Box 1.10*).

Box 1.10. *Brief technological features of large thermal plants of Chişinău*

Installed capacity at TP East is of 369 Gcal/h, and water debit is of 315 mł/h. Hot water boilers of type KVGM-180 and steam boilers of type E-25-1.4, GH-2 were installed during 1992-1995.

Installed thermal power at TP West is of 400 Gcal/h, and water debit is of 120 mł/h. Hot water boilers of type PTVM-100 were produced in 1969, and steam boilers of type DKBR-6.5/13 - in 1979 and 1981.

Installed capacity at TP South is of 310 Gcal/h, and water productivity is of 30 t/h. Hot water boilers of type KVGM-100, PTVM-30 and steam boilers of type DKVP-10/13 were installed during 1969-1986.

At TP Munceşti the steam production capacity is of 42 t/h. Steam boilers of type DKVP-10/13 were installed during 1966-1971.

Thermal plants with large and medium productivity are equipped with large-size hot water boilers of type KV and PTVM (*Annex 1.8*) and /or with steam boilers of type DKVR or DE with 25 t/h productivity (*Annex 1.7*). Thermal plant of "Dobruja Cardboard Factory" is an exception, because at the beginning it was designed to be a CHP. This plant is equipped with boilers similar with those from CHP-1.

Table 1.22. *Number and productivity of thermal plants (as of 01.01.2000)*

Type of plants	Number of plants	Type of boilers			
		steam		hot water	
		Units	Total productivity, MW	Units	Total productivity, MW
TPs with large capacity	*17*	*55*	*841*	*27*	*1786*
TPs with medium capacity	*48*	*134*	*1353*	*34*	*443*
TPs with small capacity	*3856*	*1258*	*2531*	*5418*	*3965*
Total	**3921**	**1447**	**4724**	**5479**	**6193**

Boilers of the large and medium thermal plants have a regular efficiency: at gas burning – 89-93% and at oil burning – 86-91%, e.g. corresponds to the specific fuel consumption of 38.3-36.7 kg. c.e./GJ and 39.7-37.5 kg. c.e./GJ. Small local TPs function on natural gases and coal, and the industrial ones consume residual fuel oil, being equipped with steam boilers of type E, DE or DKVR with a productivity of 1-6.5 t/h (*Annex 1.7*). These plants are equipped with hot water boilers with an productivity of 0.1-3.0 MW. The efficiency of these boilers is 70-91% when gas is used, and 60-88% when oil and coal are burned, e.g. corresponds to the specific fuel consumption of 48.8-37.5 kg. c.e./GJ and 56.9-38.8 kg. c.e./GJ (*Annex 1.9*).

For the same type of fuel the high specific consumption appears for smaller installations.

From the above mentioned, it comes out that about 60% of thermal energy used in the Republic of Moldova is produced at TPs equipped with small and less efficient boilers with an efficiency of 0.64-0.80, while the modern boilers of the same productivity have an efficiency of 0.95 and higher.

1.4.2. Comparative analysis of the thermal energy supply systems operation

Thermal energy production reduced about 7.4 times in the last ten years. In 1990 thermal plants were producing five times more than CHPs, then in 2000 production volumes almost were the same (*Figure 1.9*).

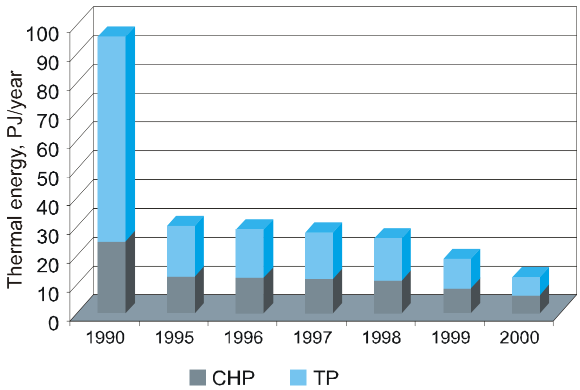

Figure 1.9. *Dynamics of thermal energy production (1990-2000)*

The structure of fuel consumption in 2000 for thermal energy production demonstrates that the largest share belongs to liquid and gas fuel consumption, and the share of solid fuel being unimportant (*Figure 1.10*).

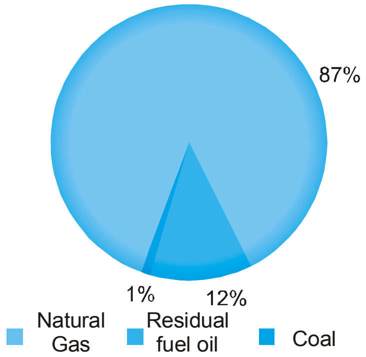

Figure 1.10. *Structure of fuel consumption for thermal energy production in 2000*

Specific fuel consumption at the country's plants (*Boxes 1.8-1.11*), belonging to the large centralized, local and autonomous systems varied in the last years (*Table 1.23*).

> **Box 1.11.** *Brief description of different types of thermal plants from the Republic of Moldova*
>
> – TP-South is the only heating and warm water supply source of Telecentru sector of Chişinău municipality. It supplies also several consumers with steam. Residual fuel oil has an unimportant share of less than 5% of the used fuels.
>
> – TP-Munceşti of Chişinău is equipped with steam boilers (total capacity – 42t/h), and supplies with technological steam the industrial enterprises from its district. It uses only gas.
>
> – The heating system of Cahul town consists of 18 TPs, which are not interconnected. Only one of these plants consumes coal.
>
> – Local TP from Durleşti, a suburb of Chişinău, consumes only coal.
>
> – Autonomous plants from Boarding School Cernoleuca (Soroca district); Corteşti (Taraclia district) and Water-Pool of the National Institute of Physical Education and Sport of Chişinău municipality consumes only one type of fuel.

As the table shows, specific fuel consumption for autonomous and local centralized heating system TPs that function only on gas and oil varies less than for large centralized heating system TPs, except for the plants consuming diesel and coal.

The higher specific consumption from Table 1.23 than those from Annexes 1.7-1.9, can be explained partially by an increased technologic self consumption of the plants and a decrease of boilers efficiency related to their expired exploitation term and lack of finances for maintenance and repairing. A double growth of specific consumption of fuel at some TPs (for example, TP Durleşti), especially in the last years (1998-2001), are due to the bad management and fuel evasions. It should be mentioned that not only coal is stolen, but also other fuels and secondary energies: heat and electricity.

Table 1.23. *Specific fuel consumption at different enterprises of the energy sector*

Power plants	Type of heating system	Thermical power, MW	Type of fuel	Specific consumption, kg.c.e. /GJ	
				1998	2000
CHP-1 Chişinău	*Large centralized heaing systems*	*455*	*Gas, residual fuel oil*	*38.1*	*40.4*
CHP-2 Chişinău	*Large centralized heaing systems*	*1,425*	*Gas, residual fuel oil*	*28.2*	*31.5*
TP-South	*Local centralized heaing systems*	*380*	*Gas, residual fuel oil*	*41.3*	*42.1*
TP-Munceşti	*Local centralized heaing systems*	*27*	*Gas, residual fuel oil*	*44.9*	*45.7*
TN-Cahul	*Local centralized heaing systems*	*117*	*Gas, coal*	*44.2*	*51.9*
TP-Durleşti	*Local centralized heaing systems*	*4.7*	*coal*	*53.0*	*96.1*
TP-BS Cernoleuca[a]	*Autonomous heating systems*	*0.88*	*coal*	*53.3*	*53.4*
TP-WP NIPES[b]	*Autonomous heating systems*	*1.05*	*Diesel oil*	*35.6*	*37.7*
TP-BS Corteşti[a]	*Autonomous heating systems*	*0.225*	*Gas*	*37.7*	*37.9*

a BS – Boarding School
b WP NIPES– Water Pool of the National Institute of Phisical Education and Sport

In order to compare the functioning of the large, local and autonomous heating systems, an analysis of the structure of fuel consumption for 1 GJ of thermal energy deliver to the consumers was carried out. It was estimated: the consumption of electricity for thermal carrier transportation through thermal networks and losses of heat in the networks. This consumption was added to the specific fuel consumption needed for thermal energy production. Specific consumption for energy production at CHPs was calculated according to data offered by CHP-2 for the electricity production efficiency – 0.35.

Electrical energy consumption for large centralized heating systems, having CHPs and TPs as thermal sources, was calculated for average conditions of these systems:

– pipe diameter – 400 mm;
– water speed – 0.75 m/s;
– water temperature – 90 ^{o}C;
– length of the network – 3 km.

For local centralized heating systems the following data were considered:

– pipe diameter – 150 mm;
- water speed – 0.5 m/s;
– water temperature – 80 ^{o}C;
– length of the network – 0.5 km.

Losses of heat in the networks were estimated at their maximum level (8-15%) in nominal conditions of thermal network function (*Table 1.24*).

The estimations made demonstrate that the total fuel consumption for large centralized heating systems with CHPs is twice less than in the local centralized heating systems with large local and industrial TPs; and 1.5 times less than for the autonomous ones. Thanks to this analysis it can be concluded that only large centralized heating systems with CHPs can be competitive with autonomous thermal plants on consumption of natural gas.

Table 1.24. *Structure of fuel consumption in different heat supply systems*

Heat source		Fuel	Specific fuel consumption for energy production, kg. c.e./GJ	Transportation expenses		Transportation losses		Total specific consumption of fuel, kg. c.e./GJ
				Electrical energy, kWh/GJ	Specific fuel consumption, kg. c.e./GJ	Thermal energy, %	Specific fuel consumption, kg. c.e./GJ	
LCHS[a]	CHPs	*gas, residual fuel oil*	*20.0*	*7.0*	*2.45*	*15.0*	*3.0*	*25.45*
LoCHS[b]	Large TPs	*gas, residual fuel oil*	*42.0*	*7.0*	*2.45*	*15.0*	*6.3*	*50.75*
	Local TPs	*gas, residual fuel oil*	*46.0*	*3.0*	*1.05*	*3.0*	*1.4*	*48.43*
	Local TPs	*coal*	*60.0*	*3.0*	*1.05*	*3.0*	*1.8*	*62.85*
AHS[c]	Autonomous TPs	*gas*	*37.0*	–	–	–	–	*37.00*
	Autonomous TPs	*coal*	*55.0*	–	–	–	–	*55.00*

a Large Centralized Heating Systems
b Local Centralized Heating Systems
c Autonomous Heating Systems

The necessary condition for the large centralized heating systems survival is to produce thermal energy and electricity at a price competitive with other options (for example, a massive import of chip electricity).

Taking into account the data on specific consumption and cost of the thermal energy at some sources in Chişinău and its suburbs for the year 2000, it can be seen that, first of all, price of the energy produced in large centralized heating systems with CHPs is 3-15 times less than at the thermal station in the local centralized heating systems; secondly, specific fuel consumption and cost of the thermal carrier in the local centralized heating systems are very high (*Table 1.25*) [9].

Table 1.25. *Main economic indexes for the year 2000 of some heat supply source of Chişinău municipality*

Heat source	Fuel used	Specific consumption, kg. c.e./GJ	Cost of the heat, MDL_{2000}/Gcal
CHP-1	*gas, residual fuel oil*	*40*	*112*
CHP-2	*gas, residual fuel oil*	*31*	*96*
TP-South	*gas, residual fuel oil*	*42*	*317*
TP-Munceşti	*gas, residual fuel oil*	*46*	*332*
TP-Coloniţa	*gas*	*55*	*1,468*
TP-Ciorescu	*gas*	*45*	*399*
TP-Vatra-2	*residual fuel oil*	*58*	*463*
TP-Sângera	*coal*	*116*	*892*
TP-Durleşti	*coal*	*96*	*490*

If the increase of 20% of specific consumption at TP-Colonita in comparison with TP-Ciorescu can be admitted, taking into account the type and the current state of the boilers (DKVR-2.5 installed in 1973 in comparison with DE-10; from 1982), the 4 times higher cost of energy is too exaggerated, being impossible to argument. In comparison with TP-Durlesti where the specific fuel consumption in the last years increased essentially: from 53 kg. c.e./GJ in 1998 to 96 kg. c.e./GJ in 2000, at TP-Sângera this index increased even more: from 53.3 kg. c.e./GJ in 1997 to 116.4 kg. c.e./GJ in 2000, and the cost increased about two times (*Table 1.23, Table 1.25*).

The coefficient of installed power use that proves the efficiency of using the heat supply system is an important factor, which determines the considerable increase of the heat cost. If in 1990, this index for the large centralized heating systems was 0.27 (normative value being 0.35-0.40), in 2000 the average coefficient of the installed power use was 0.09. In centralized heat supply systems this situation contributed to a considerable increase of the cost for thermal carrier, related to the maintenance expenses.

Nevertheless, in autonomous heat supply systems, under optimal conditions, the cost for thermal energy divided to the value of the nominal installed power use coefficient is MDL 176_{2001}/Gcal, and divided to the value of the installed power use coefficient 0.2 the cost is about MDL 200_{2001}/Gcal. Thus, the heat cost in the large centralized heating systems is less than in the autonomous ones.

It is considered that in the future, the thermal carrier cost at autonomous TPs will increase in comparison with costs at CHPs from many considerations [9]:

- differentiation of the tariffs for natural gas for engross and en detail clients;
- differentiation of the tariffs for water for engross and retail clients;
- differentiation of the tariffs for electricity for the consumers connected to the low and high voltage networks;
- tax imposing for polluted gases, (currently collected only from the large heat sources) and for autonomous TPs. Autonomous sources discharge the gases in vital spaces in comparison with CHPs, which discharge them at 180 m height.

Analyzing the above presented information we can formulate the following conclusions:

Despite the fact that the functioning CHPs have a comparatively low efficiency, used equipment and are forced to operate in inefficient regimes – the cost of produced thermal energy in the large centralized heating systems is lower than the price at the local centralized heating systems and autonomous systems of heat supply.

High prices applied to the energy produced by thermal plants from large and local centralized heating systems have no argumentation, are subjective and can be explained, especially, by bad management of facilities. This led to a low rate of collecting the payments, a situation that can be explained by insolvency of the population and low level of paying the bills for the rendered services.

Taking into consideration all fixed costs of the local centralized heating systems, including the costs of the boilers and transportation and distribution networks, the final cost of the heat is higher in comparison with autonomous systems (autonomous boilers consuming natural gas). The cost level of thermal carrier in the local centralized heating systems can be estimated at MDL 290-350$_{2001}$/Gcal, and the cost of heating for autonomous boilers consuming natural gas can be estimated at MDL 250$_{2001}$/Gcal.

Use the autonomous thermal plants (individual boilers for buildings or apartments) is feasible, especially in the regions with low heat consumption. At the same time, these can be used by the consumers who can afford, from financial point of view, to be independent from the centralized heating systems. Decentralized heating, based on the autonomous individual boilers on gas consumption, represents a option of equilibrium between payment capacity and thermal comfort in the apartments, and an individual option for each consumer.

1.5. The assessment of the greenhouse gases emissions resulted from the energy sector

The energy sector is the basis of the accelerated development of the human society during the last two centuries, as well as the cause of many environmental problems.

It is well known the existence of a tight correlation between the process of energy production and the polluting effect on the environment. During the production of energy from organic fuel containing a high rate of carbon (55-95%) – natural gas, residual fuel oil, coal – in the environment there are emitted considerable quantities of pollutant gases and solid particles. The anthropogenic emissions of gases have a direct impact on phenomena like climate change and acid rains [13].

From the direct greenhouse gases (CO_2, CH_4, N_2O, CFC, PFC, HFC, CF_4, SF_6, etc.), the carbon dioxide is the gas with the most prominent impact. The CO_2 layer in the atmosphere has the role of unidirectional filter for solar rays and for those reflected or irradiated from the surface of the planet. The increase of the CO_2 in the atmosphere disturbs the thermal balance of the Terra. The CO_2 concentration in the atmosphere rose by about 25% towards the pre-industrial period – from 275 ppmv (parts per million of volume) in the mentioned period, to 360 ppmv in the present [14]. Just tenths of degree changes in the global temperature on the soil surface are enough for the unforeseeable climate changes, and from 1856 till nowadays this index grew with 0.5^{0}C. There have appeared changes in the meteorological conditions, which prove the global change of climate: intense glacier melting, unparalleled floods, tornadoes, cyclones, drought and higher frequency of extreme temperatures [14].

On their turn, the indirect greenhouse gases (NO_x, CO, NMVOC and SO_2), especially the nitrogen oxides and the sulfur dioxide generate acid atmospheric precipitations with a considerable impact on the human health, forest ecosystems and on the agrophytocoenosis (according to the recent estimations, the losses caused by acid rains are estimated to about 6000 Euro per ton of SO_2 or NO_x emissions) [15].

The main production facilities in the Republic of Moldova are: the Moldovan Thermo-Electric Power Plant from the city Dnestrovsk (MTPP), the combined heat and power plants from Chişinău (CHP-1, CHP-2), and Bălți (CHP-North), the thermal power plants (TPs) of the Termocom S.A. from Chişinău, as well as all TPs of the ex-“Termocomenergo” Republican Production Association, whose infrastructure was transferred in 2000 to the local public authorities.

1.5.1. Methodological aspects

According to the article 12.1 (a) of the United Nations Framework Convention on the Change of Climate (UNFCCC), each signatory part is obliged to communicate to the UNFCCC executive organs the information regarding the anthropogenic emissions of all greenhouse gases that are not under the incidence of the Montreal Protocol (the Republic of Moldova ratified this convention in 1995). The emissions inventory must include data at least for he following gases: CO_2, CH_4, N_2O, NO_x, CO, NMVOC [16]. Since the sulfur dioxide is considered a pollutant with a considerable impact on the environment, as well as a subject for many regional and global conventions, according to the UNFCCC recommendations the signatories are encouraged to present data regarding the emissions of this gas as well. The assessment of the direct and indirect GHG for the period 1990-1998 in the Republic of Moldova was carried out during the elaboration of the 1st National Communication of the Republic of Moldova on the basis of the Intergovernmental Panel on Climate Change (IPCC, 1995) guide [16] and it was presented to the 6th Conference of UNFCCC parties [17]. The assessments of the direct and indirect GHG resulted from the fossil fuel combustion in the production of thermal and electric energy in the period 1990-2000 was done on the basis of the IPCC-1996 Guidelines for National Grenhouse Gas Inventories[18].

The Intergovernmental Committee on Climate Change recommended the utilization of the concept "Global Warming Potentials-GWP" for 100 years period to express other direct greenhouse gases in the units comparable to those of CO_2 emissions (CO_2 equivalent). According to the UNFCCC and IPCC recommendations, the total emissions of the main direct greenhouse gases (CO_2, CH_4, N_2O – together these gases constitute about 92% of the global direct GHG, *Figure 1.11*) were expressed in the CO_2 equivalent (*Annex 1.10*). The Global Warming Potential cannot be applied for the indirect greenhouse gases [18, 19, 20].

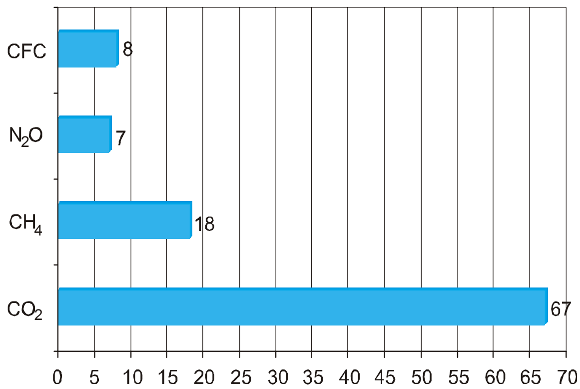

Figure 1.11. *Greenhouse Gas Emission by Relative Contribution to Global Radiative Forcing, %*

For the assessment there were used the emission coefficients expressed in GHG tones per 1 TJ of energy produced (*Annex 1.11*).

The GHG emissions are estimated on the basis of the primary data on fuel consumption, presented by the Department of Statistics and Sociology, as well as in accordance with the data presented by the Ministry of Energetics, Ministry of Education, Ministry of Health, "Termocom" JSC, the "Termocomservice" JSC and the local public authorities. The assessment of the emissions resulted from fossil fuel combustion in the production of energy in the thermal power plants from the left bank of the Nistru, for the period 1990-2000, wasn't carried out because of lack of data.

As the calculus instrument, there was used the ENPEP (ENergy and Power Evaluation Program) model software, elaborated by the Argonne National Laboratory (USA) and International Agency for Atomic Energy (IAAE). Three models from the ENPEP packet were used particularly: IMPACTS model – to estimate the impact of the energy sector on the environment, and the models WASP and BALANCE, which provide data referring to energy production and fuel consumption for each energy production unit of the national power system [21, 22, 23, 24].

1.5.2. The assessment of GHG resulted from the energy sector

I. The Moldovan Thermo-Electric Power Plant (MTPP)

In the period preliminary to the transition to the market economy, The Republic of Moldova was ranked as 7th among the 20 ecological regions from the former USSR on the degree of environment pollution [13]. This situation was due to the thermo-electric power station in Dnestrovsk, one of the most pollutant energy sources from that region. In the period 1990-2000, the energy consumption decreased considerably once with the national economy decay and with the worsening of the population standard of living. In these conditions the MTPP worked in an inefficient technological regime, being compelled to conserve the majority of the energy units. By the year 2000, at MTPP were in operation only the energy units No. 11 and 12, on the natural gases consumption. The rate of carbon in such type of fuel constitutes 55-60%.

So, by the year 2000, as a result of the existent problems in the national economy and of the general reduction of energy consumption, the direct GHG resulted from the organic fuel combusted at MTPP, abated 7 times in comparison with the year 1990.

The assessment of direct GHG emissions. The total emissions of greenhouse gases reckoned directly through the Global Warming Potential for 100 years expressed in CO_2 equivalent, resulted from the MTPP, were of 9,975, 3,677 and 1,402 Gg respectively in the years 1990, 1995, 2000. The period 1990-2000 was characterized by a continuous tendency of such types' emissions diminution. In 2000 the total direct GHG emissions in MTPP constituted only 14% towards 1990 (*Table 1.26*).

The Implied Emission Factor (IEF) represents the real ratio between the total direct GHG and the total fuel consumption from the energy source [16,17]. This factor depends on the features of the used fuel, on the combustion conditions, on the technologies and strategies regarding the control of pollutant gases emissions. The comparison with the IEF ascertained in different technologies and energy sources also permits to identify some discrepancies in the data regarding the fuel consumption and the GHG registered. As it is seen in the Table 1.26, the reduction of the IEF in the period 1990-2000 from 76.21 to 55.87 t_{GHG}/TJ reflects the situation when in the MTPP there was a tendency to replace the more pollutant types of fuel with a high rate of carbon (residual fuel oil, coal) with less pollutant fuel – natural gas.

The direct GHG emissions resulted the combustion of all types of fuel at MTPP had, in 1990, the following origin: 22.8% from the natural gas, 33.1% from residual fuel oil and 44.1% from coal combustion. In the period 1998-2000, at TPP only the natural gas has been used for thermal and electric power production (*Figure 1.12*).

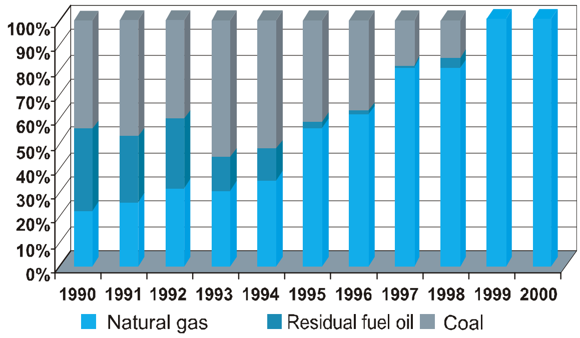

Figure 1.12. *The share of different types of fuel in the total direct GHG at MTPP*

The assessment of the indirect GHG emissions. In the period 1990-2000 at the MTPP there was registered a considerable diminution of indirect GHG emissions resulted from organic fuel combustion.

a. NO_x emissions

In 1990 the total NO_x emissions resulted from the fossil fuel combustion at MTPP have been estimated to 28.86 Gg (*Table 1.27*). The NO_x gases emissions at MTPP in 1990 resulted from the combustion of: natural gases – 21.13%, residual fuel oil – 29.79% and coal – 49.07%. By 1998 the NO_x gases emissions resulted from: 77.84% from natural gases, 3.89% from residual fuel oil and 18.27% from coal combustion. Since only natural gas has been used in the period 1999-2000 for energy production at MTPP, the registered NO_x emissions resulted only from this type of fuel. In 2000 the NO_x emissions constituted only 13% from the 1990 emissions volume.

Table 1.26. *The dynamics of fuel consumption and of direct GHG emissions resulted from Moldovan TPP (1990-2000)*

The year	Fuel consumption, TJ				Direct GHG emissions, Gg CO_2 equivalent				Implied emission factor, t_{GHG}/TJ
	Gas	Residual fuel oil	Coal	**Total**	Gas	Residual fuel oil	Coal	**Total**	
1990	40,667.2	42,999.3	47,211.8	130,878.3	2,272.1	3,304.2	4,398.4	9,974.7	76.21
1991	40,674.0	30,476.1	44,945.0	116,095.1	2,272.5	2,341.8	4,187.2	8,801.6	75.81
1992	43,340.0	27,847.7	32,700.8	103,888.4	2,421.5	2,139.9	3,046.5	7,607.8	73.23
1993	28,230.5	9,163.3	30,601.3	67,995.1	1,577.3	704.1	2,850.9	5,132.3	75.48
1994	34,715.1	9,163.3	31,337.0	75,215.5	1,939.6	704.1	2,919.5	5,563.2	73.96
1995	37,020.5	1,049.0	16,404.3	54,473.7	2,068.4	80.6	15,28.3	3,677.3	67.51
1996	41,516.6	948.5	14,981.8	57,446.8	2,319.6	72.9	1,395.7	3,788.2	65.94
1997	37,522.7	243.4	5,237.2	43,003.2	2,096.4	18.7	487.9	2,603.1	60.53
1998	28,871.5	1081.9	3,389.3	33,342.6	1,613.1	83.1	315.8	2,012.0	60.34
1999	27,512.7	0.0	0.0	27,512.7	1,537.2	0.0	0.0	1,537.2	55.87
2000	25,088.1	0.0	0.0	25,088.1	1,401.7	0.0	0.0	1,401.7	55.87

Table 1.27. *The dynamics of indirect GHG emissions resulted from combustion fossil fuels at the Moldovan TPP*

Year \ Noxes	NO_x	CO	NMVOC	SO_2
1990	*28.86*	*2.40*	*0.65*	*185.09*
1991	*25.68*	*2.17*	*0.58*	*165.80*
1992	*21.88*	*1.94*	*0.52*	*126.28*
1993	*15.25*	*1.31*	*0.34*	*101.35*
1994	*16.44*	*1.46*	*0.38*	*103.57*
1995	*10.68*	*1.08*	*0.27*	*50.49*
1996	*10.91*	*1.14*	*0.29*	*46.10*
1997	*7.25*	*0.86*	*0.22*	*16.03*
1998	*5.56*	*0.66*	*0.17*	*11.29*
1999	*4.13*	*0.55*	*0.14*	*0.00*
2000	*3.76*	*0.50*	*0.13*	*0.00*

b. CO emissions

In 1990 the CO emissions at the MTPP constituted about 2.40 Gg (*Table 1.27*). These emissions resulted in 1990 from the combustion of: natural gas – 33.85%, residual fuel oil – 26.85% and coal – 39.30%. The share of the natural gas in the CO emissions increased in 1998 to 87.30%, while the share of the residual fuel oil and coal decreased to 2.45% and 10.25% respectively. In the period 1999-2000 the share of natural gases in the total CO emissions at MTPP reached the rate of 100%. The CO emissions registered in 2000 were estimated to 0.50 Gg, constituting approximately 21% of 1990 emissions' volume.

c. NMVOC emissions

In 1990 the emissions of non-methanic volatile organic compounds (NMVOC) were estimated to 0.65 Gg. The period 1990-2000 was characterized by a considerable diminution of these emissions (Table 1.27). The emissions of NMVOC in 1990 resulted from the combustion of: natural gas – 31.07%, residual fuel oil – 32.85% and coal – 36.07%. In the next period there existed a tendency of increasing the share of natural gases in the NMVOC emissions. In the year 2000 these emissions were estimated to 0.13 Gg, representing only 19% from the rate of the NMVOC emissions registered in 1990.

d. SO_2 emissions

In 1990 the emissions of SO_2 were estimated to 185 Gg. The SO_2 emissions in 1990 resulted from the combustion of residual fuel oil (23.12%) and coal (76.88%). In the further period, once with the diminution of oil fuel consumption, the share of coal in SO_2 emissions grew continuously, constituting in 1998 about 98% from its total.

The emissions of the sulfur dioxide constituted in 1998 only 6% from the volume registered in the reference year – 1990. Since in the period 1999-2000 only natural gases were used at MTPP, no SO_2 emissions were registered any more (*Table 1.27*).

II. Combined heat and power production plants

In the Republic of Moldova there are three municipal CHPs (CHP-1, CHP-2, Chişinău, and CHP-North, Bălţi) and nine CHPs on the estate of sugar factories in Briceni, Donduşeni, Drochia, Cupcini, Glodeni, Făleşti, Alexăndreni, Gârbova, Ghindeşti.

In the period 1990-2000 the total fuel consumption at all domestic CHPs decreased almost twice, constituting in 2000 only 43% from the rate of fuel consumption in 1990. In the period analyzed, the volume of GHG resulted from the CHPs decreased considerably constituting in 2000 39.5% from the 1990 volume. If in 1990 the share of CHPs in the structure of GHG was relatively equal (except CHP-2), by 2000 this structure changed considerably: the share of CHP-2 and of the CHP-SF (sugar factories) in the total volume of the GHG increase, while that of CHP-1 and CHP-North decreases (*Figure 1.13*).

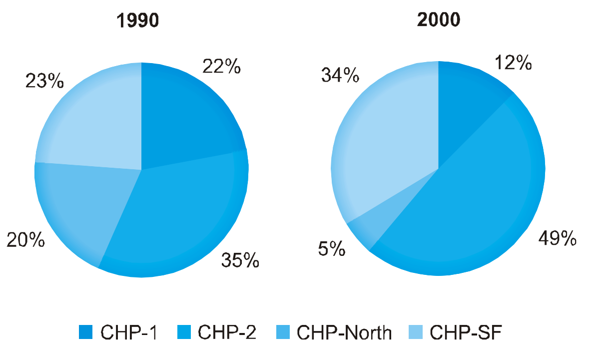

Figure 1.13. *The contribution of domestic CHPs to direct GHG emissions in the years 1990 and 2000, resulted from combined production of electrical and thermal energy*

This situation is explained by the fact that during the last five years CHP-1 and CHP-North have considerably reduced their thermal energy production and worked in an inefficient regime. That development of the events was caused especially by the low solvency of the population, so that the delivery of the thermal carrier to the residential sector was made only during the cold period of the year.

The assessment of the direct GHG emissions. The total GHG direct emissions (estimated through the Global Warming Potential for 100 years) expressed in CO_2 equivalent, resulted from the CHPs amounted in 1990, 1995 and 2000 to 2,600, 1,346 and, respectively, 1,066 Gg (*Figure 1.14*).

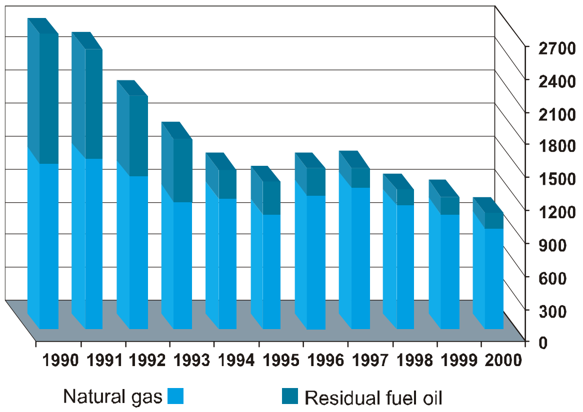

Figure 1.14. *The dynamics of emissions and share of different types of fuel on the total direct GHG emissions from the CHPs (1990-200), Gg*

In the period 1990-2000 the total direct greenhouse gases emissions from the CHPs decreased with 61% towards the level of 1990, the period under consideration being characterized by a continuous tendency of reduction of such kinds of emissions.

The direct GHG emissions expressed in CO_2 equivalent, resulted from the combustion of all types of fossil fuel at the CHPs, had in 1990 the following origin: 56.20% from natural gas and 43.80% from residual fuel oil combustion. In the last years the emissions resulted from the combustion of liquid fuel reduced, and the emissions resulted from the combustion of gas fuel considerably increased. So, in 2000, the direct GHG emissions expressed in CO_2 equivalent resulted from the natural gas combustion – 87.64%, and from residual fuel oil combustion – 12.36%. As a result of considerable decrease of fuel consumption, the emissions resulted from its combustion reduced about 2.5 times, inclusively through the combustion of: residual fuel oil – 9 times, natural gas – 1.6 times. The period 1990-2000 was characterized by a considerable tendency to reduce the volume of total direct GHG emissions at the thermo-electric power plants. So that in 2000 the volume of these emissions at the thermo-electric power plants from the country constituted: at the CHP-1, CHP-2 and CHP-North respectively: 22.7%, 54.9%, 9.8%, and of the CHPs of the sugar fabrics – 56% of the volume registered in 1990 (*Annex 1.12*).

This situation is caused by the worsening of the population standard of living, including the non-payment of the invoices for the performed services, the antiquation of the technical machinery, imperfect administering conditions, and the inadequate taxation policy. Taken together, the named factors caused the diminution of the demand for electric and thermal energy from the domestic CHPs, so that in the period analyzed the specific fuel consumption and the direct GHG expressed in CO_2 equivalent at the domestic CHPs registered considerable reductions (*Annex 1.13*).

Unlike the other two municipal power plants (CHP-1, CHP-North), in the period 1990-2000 the CHP-2 worked in a regime more or less close to the nominal one, so that the specific fuel consumption was much inferior to this rate at other CHPs. This may be explained by the fact that, in comparison with other CHPs plants the machinery in CHP-2 is more modern, since it is a recently built power station (for instance, the electric efficiency of CHP-2 is almost twice as for the other two municipal power plants).

The increase of the indices at CHP-1 during the last years is due to the fact that it operated only in the cold period of the year when thermal energy was required.

The assessment of indirect GHG emissions. During the period 1990-2000, at the domestic CHPs there was registered a considerable diminution of indirect GHG emissions (almost twice – the NO_x, CO and NMVOC emissions and almost 9 times – the SO_2 emissions). If the diminution of the NO_x, CO and NMVOC emissions in the analyzed period may be explained by the tendency to quit the formerly used fuel (the replacement of residual fuel oil by natural gases), as well as by the general reduction of production capacities and the work in an inefficient regime (in the conditions of low demand for thermal energy from the population of the country), the considerable diminution of SO_2 emissions is due mainly to the fact that in the period 1990-2000 at the domestic CHPs there was reduced the utilization of expensive and polluting type of fuel – residual fuel oil. The evolution of the indirect GHG in the period 1990-2000 is showed in the *Table 1.28*.

Table 1.28. *The dynamics of GHG emissions from domestic CHPs, Gg*

Year	NO_X	CO	NMVOC	SO_2
1990	*6.99*	*0.83*	*0.21*	*23.09*
1991	*6.63*	*0.80*	*0.20*	*19.62*
1992	*5.52*	*0.67*	*0.17*	*14.31*
1993	*4.53*	*0.55*	*0.14*	*11.16*
1994	*3.79*	*0.48*	*0.12*	*5.34*
1995	*3.47*	*0.44*	*0.11*	*5.82*
1996	*3.80*	*0.49*	*0.12*	*4.78*
1997	*3.82*	*0.49*	*0.12*	*3.55*
1998	*3.31*	*0.43*	*0.11*	*2.81*
1999	*3.15*	*0.41*	*0.10*	*3.13*
2000	*2.75*	*0.35*	*0.09*	*2.57*

a. NO_x emissions

In 1990 all the NO_x emissions resulted from the combustion of fossil fuel at CHPs were estimated to about 6.99 Gg (*Table 1.28*). If in 1990 the contribution of natural gases and residual fuel oil in the structure of NO_X gases emissions at the CHPs was balanced (residual fuel oil – 56%, the natural gases –44%), in 2000 this situation changed considerably: the share of natural gases is 88%, while that of the residual fuel oil – only 12%. In 1995 the NO_x emissions were estimated to about 49.7%, and in 2000 – to 39% from the 1990 volume of these emissions.

b. CO emissions

The CO emissions from the CHPs constituted approximately 0.83 Gg in 1990 (Table 1.28). These emissions resulted in 1990 from the combustion of the natural gas (62.9%) and residual fuel oil (37.1%). The contribution of natural gases in the CO emissions amounted in 2000 to 90%. The CO emissions registered in 1995 and 2000 were estimated to 0.44 and 0.35 Gg, constituting, respectively, only 52.8 and 42.8% from the 1990 volume of these emissions.

c. NMVOC emissions

The emissions of non-methane volatile organic compounds (NMVOC) were estimated in 1990 to 0.21 Gg (*Table 1.28*). The period 1990-2000 was characterized by a considerable diminution of these emissions resulted from the fossil fuel combustion at CHPs. The NMVOC emissions for the years 1995 and 2000 were estimated to 0.11 and 0.09 Gg, that is 53% and, respectively 43% from the 1990 volume of NMVOC emissions.

d. SO_2 emissions

In 1990 the SO_2 emissions were estimated to 23 Gg (*Table 1.28*). In the following period there were registered a considerable reduction of the sulfur dioxide resulted from CHPs. This is explained by the diminution of residual fuel oil consumption at the domestic CHPs. The sulfur dioxide in the years 1995 and 2000 represented, respectively, only 25% and 11% from the volume registered in the reference year – 1990.

III. Thermal plants (TPs)

Generalizing the data referring to the fuel consumption and GHG, the domestic thermal plants were considered according to the departmental subordination:

- The “Termocom” JSC thermal plants – 22 units;
- The thermal plants subordinated to the Ministry of Education (MoE) – 56 units;
- The thermal plants subordinated to the Ministry of Health (MoH) – 8 units;
- The thermal plants subordinated to the local public authorities, which were subordinated to the RPA “Termocomenergo” till the year 1999 – 193 units.

In the period 1990-2000 the total GHG resulted from the thermal plants from the Republic of Moldova decreased 2.6 times. This fact is due mainly to the drastic reduction, almost 5 times, of the thermal energy at the thermal plants subordinated to the local public authorities. In the structure of direct GHG emissions the largest contribution in 1990 had the thermal plants subordinated to the “Termocom” JSC and to the ex-“Termocomenergo” RPA. Although the generating units subordinated to the mayoralties and to the “Termocom” JSC remain to be the main generators of GHG emissions, in the year 2000 the share of these sources changes: the contribution of the thermal plants subordinated to “Termocom” JSC, to the Ministry of Education, and to the Ministry of Health increases, while the share of the thermal plants subordinated to the mayoralties diminishes (*Figure 1.15*).

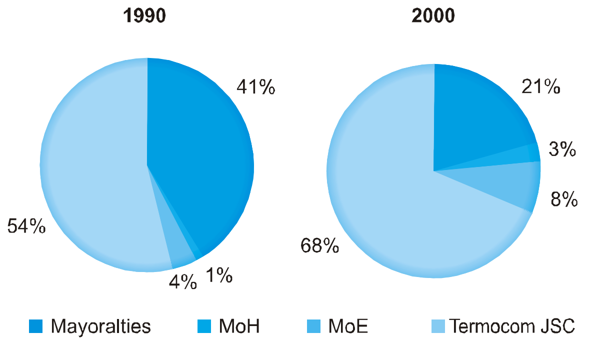

Figure 1.15. *The contribution of various thermal plants to direct GHG emissions, (1990, 2000)*

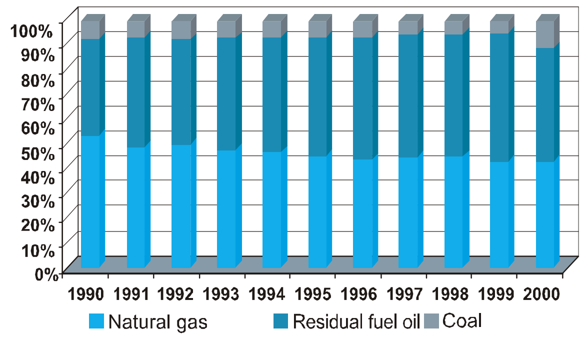

Figure 1.16. *Breakdown of direct GHG emissions by used fuels for domestic thermal plants (1990-2000)*

The assessment of direct GHG emissions. The total emissions of greenhouse gases expressed in CO_2 equivalent, resulted from the thermal plants, were estimated in the years 1990, 1995 and 2000 to 809.6 Gg, 615.5 Gg and, respectively, 315.1 Gg. In the period 1990-2000 the total emissions of greenhouse gases from the TPs decreased with 61% towards the 1990 level, this period being characterized by a continuous tendency of this type of emissions reduction (*Table 1.29*).

As a result of the general diminution of fuel consumption, the emissions resulted from its combustion decreased considerably, including those from the utilization of: coal – 1.6 times, residual fuel oil – 2.2 times, and natural gases – 3.2 times. The direct GHG emissions resulted from the combustion of all types of fuel at the thermal plants had in 1990 the following origin: 53.1% from the combustion of natural gas, 39.1% from the residual fuel oil, and 7.8% from coal (*Figure 1.16*).

In the following years there was reduced the share of emissions resulted from the gas fuel combustion, while the share of the emissions resulted from the combustion of liquid and solid fuel increased. So in 2000 the direct GHG expressed in CO_2 equivalent resulted from: natural gas combustion – 42.1%, residual fuel oil combustion – 45.6%, coal combustion – 12.3%. This situation is explained mainly by the fact that, unlike the TPs subordinated to the local public authorities (mainly using natural gas), that operated in an inefficient regime and with frequent stoppage (especially after 1995), the thermal plants subordinated to "Termocom" JSC, the Ministry of Education and the Ministry of Health worked in the period 1995-2000 more stably. In the same time, coal and residual fuel oil consumption at the TPs subordinated to the local public authorities in the period 1995-2000 decreased considerably, while the this index at the TPs subordinated to the MoE and MoH has only slightly decreased towards the 1994 volume of fuel consumption. These factors contributed to the increase of the coal and residual fuel oil contribution in the structure of the total direct GHG emissions resulted from the combustion of fossil fuel at the domestic TPs.

Table 1.29. *The dynamics of the fuel consumption and GHG emissions resulted from combustion of the fossil fuels at domestic thermal plants*

Year	Consumption of fuels, TJ				GHG direct emissions, Gg CO_2 equivalent			
	Termocom JSC	MoE	MoH	Mayoralties	Termocom JSC	MoE	MoH	Mayoralties
1990	3,263.79	355.03	88.24	5,844.52	439.97	32.61	8.22	328.78
1991	3,357.69	353.62	91.78	6,413.02	434.18	32.56	8.55	415.55
1992	2,425.14	321.85	86.47	5,572.28	302.93	29.60	8.06	360.18
1993	2,365.97	327.35	69.83	4,925.47	303.72	30.00	6.51	320.17
1994	2,167.11	312.64	75.71	5,047.28	282.28	28.63	7.05	328.67
1995	2,074.18	270.57	68.80	4,812.41	266.71	25.00	6.41	317.36
1996	2,895.91	282.12	78.46	4,812.22	375.57	26.09	7.31	319.90
1997	3,071.71	277.56	60.38	3,778.26	402.65	25.61	5.62	247.30
1998	3,146.36	283.30	86.02	3,559.69	418.76	26.12	8.00	232.02
1999	4,212.75	268.25	87.83	2,696.86	535.26	24.69	8.17	178.70
2000	1,620.22	267.54	87.21	991.59	217.63	24.66	8.11	64.64

Table 1.30. *Direct GHG emissions expressed in CO_2 equivalent derived from the production of thermal energy at various CHPs and TPs*

Sources	Type of source	Thermal capacity, MW	Fuel	Direct GHG emissions, t /TJ
CHP-1	Municipal	*455*	*gas, residual fuel oil*	*32.5 - 56.3*
CHP-2	Municipal	*1425*	*gas, residual fuel oil*	*22.2 - 33.4*
CHP-North	Municipal	*610*	*gas, residual fuel oil*	*55.4 - 73.3*
TP-South, Chişinău	District	*380*	*gas, residual fuel oil*	*69.8 - 70.6*
TP-Munceşti, Chişinău	Industrial	*27*	*gas, residual fuel oil*	*74.8 - 76.2*
TN-Cahul	18 district and industrial TPs	*117*	*gas, coal*	*73.5 - 87.5*
TP-Durleşti	Local	*4.7*	*coal*	*150.2 - 275.1*
TP-BS Cernoleuca [a]	Autonomous	*0.88*	*coal*	*152.6*
TP-WP NIPCS [b]	Autonomous	*1.05*	*Diesel*	*74.6 - 79.2*
TP-BS Corteşti [a]	Autonomous	*0.225*	*gas*	*62.9*

Unlike the CHPs, in the TPs that operate on natural gas and residual fuel oil consumption the specific direct GHG emissions have close rates (with the exception of coal consuming TPs) (*Table 1.30*). This is due to the fact that almost all the TPs from the country use identical technologies with similar efficiencies.

To compare the specific direct GHG emissions at different types of heat sources expressed in direct GHG emissions per one TJ of thermal energy delivered to the consumer, there was used the total conventional fuel consumption. As it is showed in the Table 1.31, the total fuel consumption as well as the average rates of direct GHG emissions per unit of energy produced, are twice smaller in the CHPs than at the large TPs and 1.5 times smaller than in the autonomous thermal plants.

Table 1.31. *Structure of consumption of fuel and emissions in various systems of heat supply*

Heat source	Fuel	Total consumption of fuel, t.c.e./TJ	Specific emissions of direct GHG, t/TJ
CHPs	*gas, residual fuel oil*	*25.45*	*42.4*
Largi TPs	*gas, residual fuel oil*	*50.75*	*85.3*
Local TPs	*gas, residual fuel oil*	*48.43*	*80.8*
Local TPs	*coal*	*62.85*	*84.5*
Autonomous TPs	*gas*	*37.00*	*61.4*
Autonomous TPs	*coal*	*55.00*	*157.4*

Therefore we see that although in the Republic of Moldova the situation at the CHPs depends in a great extent on the administering conditions, the thermal charge, precarious technical conditions caused by the antiquation of the machinery, the most efficient technologies and respectively the less polluting energy sources are the CHPs, while the most polluting type of fuel, the coal, is presently used only at the thermal plants.

The assessment of indirect GHG emissions. Unlike other energy generation sources (MTPP, CHP-1, CHP-2 and CHP-North), the TPs have a much lower share of indirect GHG emissions.

As a result of the economic crisis, of the worsening of the standards of living and the population insolvency, the domestic TPs operated during the period 1990-2000 inefficiently, even in the cold season. This situation had a strong influence on the degree of indirect greenhouse emissions GHG resulted from the fossil fuel combustion at the TPs (*Table 1.32*).

Table 1.32. *The trend of the indirect GHG emissions resulted from burning fossil fuels at power plants, Gg*

Year \ Noxes	NO_x	CO	NMVOC	SO_2
1990	*2.11*	*0.24*	*0.06*	*7.99*
1991	*2.32*	*0.26*	*0.07*	*9.50*
1992	*1.82*	*0.21*	*0.05*	*7.39*
1993	*1.72*	*0.19*	*0.05*	*7.22*
1994	*1.68*	*0.19*	*0.05*	*7.19*
1995	*1.60*	*0.18*	*0.04*	*7.03*
1996	*1.90*	*0.21*	*0.05*	*8.56*
1997	*1.77*	*0.20*	*0.05*	*7.82*
1998	*1.78*	*0.20*	*0.05*	*7.76*
1999	*1.94*	*0.22*	*0.05*	*8.70*
2000	*0.81*	*0.09*	*0.02*	*3.82*

a. NO_x emissions

In 1990 the total NO_x emissions generated from the fossil fuel combustion at the power plants were estimated to about 2.11 Gg (Table 1.38). The NO_x

gases emissions from the CHPs resulted in 1990 from the combustion of natural gas – 52.5%, residual fuel oil – 39.1% and coal – 8.5%.

By the year 2000 the share of the NO_x gases emissions changed considerably, so that the share of these gases decreased to 41.9% from gas combustion, the share of coal and residual fuel oil increased to 46.0% and, respectively, 12.2%. In 2000 the NO_x emissions were estimated to only 42% from the 1990 rate of these emissions.

b. CO emissions

In 1990 the emissions of CO from the TPs constituted 0.24 Gg. These emissions resulted in 1990 from the combustion of: natural gas – 61.0%, residual fuel oil – 34.1% and coal – 4.9%. By the year 2000 the contribution of natural gas in the CO emissions decreased to 51%, while that of the residual fuel oil and coal increased respectively to 42% and 7%. The CO emissions registered in 2000 were estimated to 0.09 Gg, constituting only 41% from the 1990 rate of this gas emissions.

c. NMVOC emissions

The emissions of non-methane volatile organic compounds (NMVOC) resulted from the fossil fuel combustion during the production of thermal energy at the domestic power plants were estimated to 0.06 Gg in 1990. The period 1990-2000 was characterized by a considerable diminution of these emissions resulted from the combustion of fossil fuel at the TPs. For the years 1995 and 2000 the emissions of these gases were estimated to 0.04 Gg and respectively 0.02 Gg. These emissions in 1990 derived from the combustion of: natural gas – 61.0%, residual fuel oil – 34.1% and coal – 4.9%. The share of natural gas in the NMVOC emissions reduced by the year 2000 to 50.8%, while that of the residual fuel oil and coal increased to 41.8% and respectively 7.3%.

d. SO_2 emissions

In 1990 the total SO_2 emissions resulted from the combustion of fossil fuel at the power plants were estimated to 7.99 Gg and derived from the liquid and solid fuel combustion. In 2000 the sulfur dioxide emissions represented only 44% from the 1990 rate. In the period 1990-2000 the share of residual fuel oil and coal in the SO_2 emissions changed inconsiderably, 77.3-73.6% for the residual fuel oil, and 22.7-26.4% for the coal.

IV. The assessment of total GHG emissions from the energy sector

In the Republic of Moldova the GHG emissions generators are the MTPP, 12 CHPs and about 3,921 TPs of different capacities. The period of transition to the market economy (1990-2000) was characterized by a deep economic decline. In these conditions the energy sector of the Republic of Moldova worked inefficiently, so that the rate of energy produced, fuel consumption and, implicitly, the GHG emissions diminished. In the period under consideration the direct GHG emissions decreased almost 5 times. In 1990 the highest contribution in the structure of the total GHG emissions had the MTPP, 74% from the total. Subsequently, especially after the year 1995, the share of the MTPP in the total GHG emissions decreases considerably to 50%. The contribution of CHPs and of TPs, on the contrary, increases constituting in the year 2000 38% and, respectively, 11% (*Figure 1.17*).

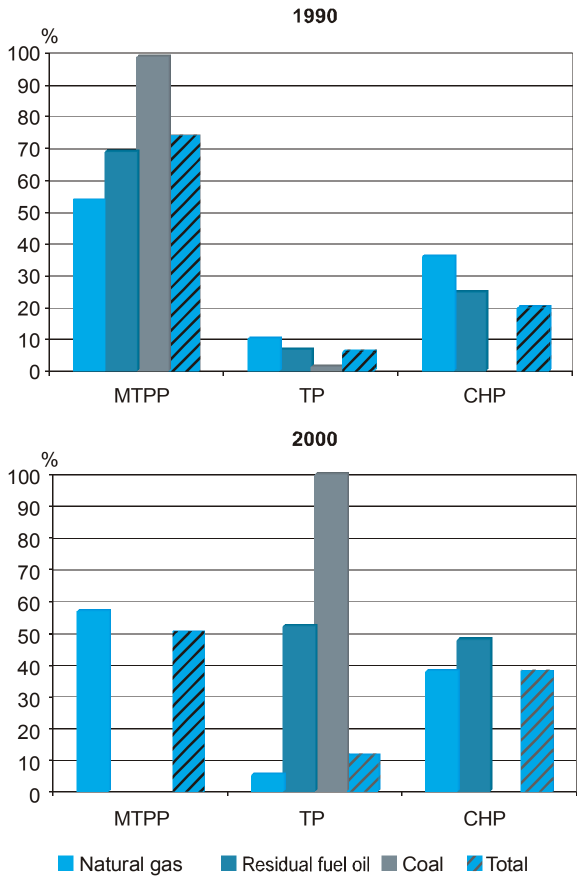

Figure 1.17. *The contribution of different emission sources and of different types of fuel in the structure of the total direct GHG (the years 1990, 2000)*

In the period under consideration there also changed considerably the share of fuel used at the energy sources in the structure of the total direct GHG. So, if in the year 1990 98.6% of the total GHG resulting from the combustion of coal proceeded from the MTPP, in the year 2000 the situation completely changed, since 100% of this type of emissions resulted from the power plants (no coal is consumed at the CHPs, while at the MTPP only natural gas has been consumed since 1998).

In the period under consideration the contribution of generating sources in the structure of total GHG emissions resulted from the natural gases combustion was relatively constant. After 1994, when at the MTPP there was initiated the process of replacing the coal and residual fuel oil consumption with natural gases, the share of this source in the structure of the total direct GHG emissions resulted from the residual fuel oil combustion is constantly decreasing. In the year 2000 about 52% of these emissions proceeded from the TPs, and the rest – from the CHPs (no residual fuel oil has been consumed at the MTPP in the period 1998-2000).

The assessment of the total direct GHG emissions. The rate of the direct GHG emissions resulted from the fossil fuel combustion in the process of thermal and electric energy production in the Republic of Moldova were estimated on the basis of the data obtained through the inventorying of the GHG emissions. The dynamics of these emissions is presented in the *Table 1.33.*

Table 1.33. *The dynamics of direct GHG emissions resulted from energy sector (1990-2000)*

Year	Direct GHG emissions expressed in CO_2 equivalent, Gg				Direct GHG emissions, tons per capita
	Natural gas	Fuel oil	Coal	Total	
1990	4,219.3	4,803.0	4,460.9	13,483.2	3.09
1991	4,266.2	3,739.9	4,250.1	12,256.2	2.81
1992	4,171.2	3,170.3	3,101.7	10,443.2	2.40
1993	3,072.5	1,572.7	2,899.9	7,545.0	1.74
1994	3,434.2	1,276.4	2,965.0	7,675.6	1.76
1995	3,393.4	670.4	1,571.1	5,635.0	1.30
1996	3,864.2	675.2	1,446.6	5,986.0	1.38
1997	3,698.2	536.1	527.6	4,761.9	1.10
1998	3,055.5	564.4	354.8	3,974.6	0.92
1999	2,914.2	547.3	39.4	3,500.8	0.81
2000	2,468.3	275.6	35.5	2,779.4	0.65

As it is seen from the Table, in the year 2000 the total direct GHG emissions expressed in CO_2 equivalent decreased 1.9 times towards the year 1995, and 4.9 times towards the year 1990. The decrease was caused by the general diminution of fuel consumption and the increase of the natural gas share in the structure of fuel consumed in the thermal and electric energy production, especially at the MTPP.

According to the “First National Communication of the Republic of Moldova elaborated under the United Nations Framework Convention on Climate Change”, it is stipulated that the rate of emissions registered in 1995 in the energy sector will be exceeded only in the year 2010 [17].

In the year 2000 there also decreased the direct GHG per capita proceeded from the energy sector, 4.8 times towards the year 1990.

The assessment of the indirect GHG emissions. In the period 1990-2000 the indirect GHG emissions generated by the energy sector have considerably reduced: the NO_x emissions decreased 5.2 times, CO_2 emissions – 3.7 times, the NMVOC emissions – 3.9 times, those of SO_2, respectively, 34 times. This situation is explained both by the reduction of the general fuel consumption and by the process of replacing the most pollutant types of fuel – the residual fuel oil and the coal, with other less pollutant – natural gases. The dynamics of the total indirect GHG emissions resulted from the fossil fuel combustion in the period 1990-2000 is presented in the *Table 1.34.*

Tabelul 1.34. *The dynamics of total indirect GHG emissions resulted from combustion of fosil fuels in energy sector, Gg*

Noxes / Year	NO_x	CO	COVNM	SO_2
1990	37.96	3.47	0.92	216.18
1991	34.63	3.23	0.85	194.91
1992	29.22	2.82	0.74	147.98
1993	21.50	2.06	0.53	119.73
1994	21.91	2.13	0.54	116.10
1995	15.76	1.70	0.43	63.34
1996	16.61	1.84	0.46	59.45
1997	12.84	1.55	0.39	27.40
1998	10.65	1.29	0.32	21.87
1999	9.21	1.17	0.29	11.83
2000	7.33	0.95	0.24	6.39

a. NO_x emissions

In 1990 the total NO_x emissions proceeded from the combustion of fossil fuel in the energy sector were estimated to 37.96 Gg. In the year 2000 the NO_x emissions decreased considerably in comparison with their rate in 1990. In the period 1990-2000 the contribution of CHPs and of TPs in the structure of NO_x emissions was increasing, while that of the MTPP was decreasing (*Figure 1.18*). this situation is explained by the drastic diminution of coal and residual fuel oil consumption at the MTPP in the period 1994-1998.

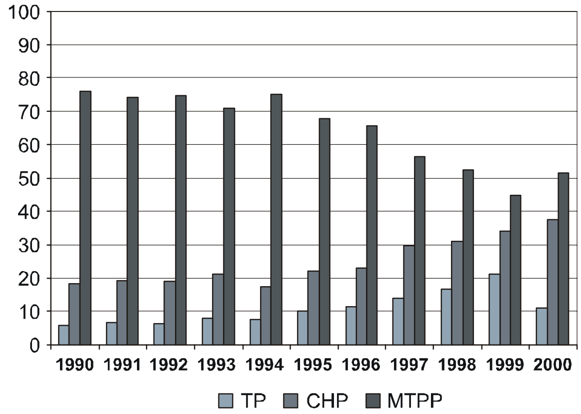

Figure 1.18. *The contribution of various energy sources in the structure of total emissions of NO_x, % (1990-2000)*

b. CO emissions

The CO emissions generated by the energy sector constituted in 1990 about 3.47 Gg (Figure *1.19*). The CO emissions registered in the year 2000 were estimated to 27% from these gas emissions in 1990. In the energy sector this situation is explained by the reduction of fossil fuel containing a high rate of carbon consumption (coal – over 145 times, residual fuel oil – over 14 times).

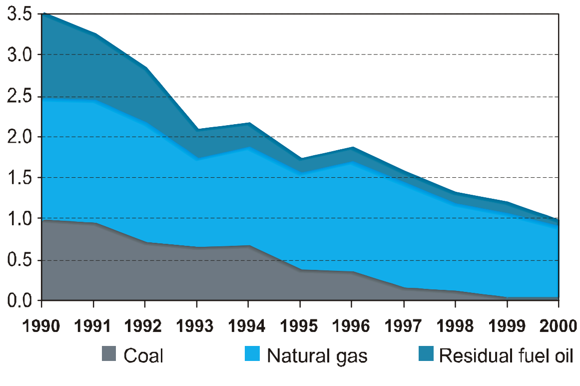

Figure 1.19. *The trend of total CO emissions and the contribution of different fossil fuels, Gg (1990-2000)*

c. NMVOC emissions

The emissions of non-methanic volatile organic compounds proceeded from the combustion of fossil fuel in the process of thermal and electric energy production in our country were estimated in 1990 to 0.92 Gg (*Figure 1.20*). The period 1990-2000 was characterized by a considerable diminution of this gas emissions resulted from the fossil fuel combustion in the energy sector. In the year 2000 these emissions were estimated to only 0.22 Gg.

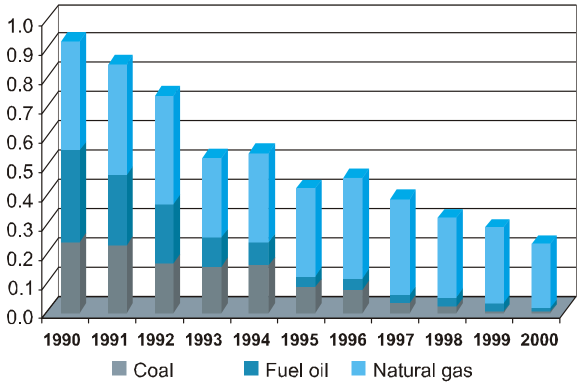

Figure 1.20. *The trend of total NMVOC emissions and the contribution of different fossil fuels, Gg (1990-2000)*

d. SO_2 emissions

In 1990 the total SO_2 emissions proceeded from the fossil fuel combustion at the production of thermal and electric energy were estimated to 216.18 Gg (*Table 1.38*), resulting from the liquid and solid fuel combustion: at the MTPP – 85.6%, the CHPs – 10.7% and the power plants – only 3.7% (*Figure 1.21*). In 2000 the sulfur dioxide represented only 6% from the rate registered in 1990. This situation is explained by a drastic reduction of the solid fuel consumption in the period 1994-1998, especially at the MTPP.

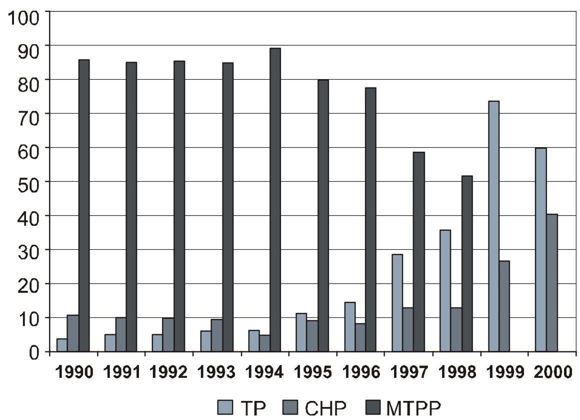

Figure 1.21. *The share of sources of SO_2 emissions generation, % (1990-2000)*

1.6. Directions of energy sector development in highly industrialized countries

1.6.1. The particularities of the energy sector development

The energy sector, formed of the electricity, heat and fuel supply sectors, has a strategic function as well as an important impact on the social and economical life in any country.

In the industrialized countries, until recently, the organization of the energy sector was based on the so-called vertically integrated structures – private and state companies, which included all or almost all segments of the energy cycle (starting with the production of primary energy resources till the delivery of thermal and electric energy).

Nevertheless, by the 80s-90s of the XX-th century, the EU countries and other developed states (the USA, Canada, Japan, Russia etc.) acknowledged that the old organization of the energy sector became non-efficient and unable to ensure a continuous economic growth. Under this situation, tens of states started a deep reformation of the energy sector, pointed to the liberation of the energy market. These radical transformations are in full progress on the American continent and in the Western Europe, extending swiftly towards the Central and East Europe.

Another global trend, specific to electricity sector especially, is the promotion of distributed generation concept. In some extents it is a return to the times of Thomas Edison and Dolivo-Dobrovolski, when there were built small-capacity power plants only for the local consumers energy supply.

Starting with the 1970s, it turned out to be more and more difficult to find a location for large-capacity nuclear-electric and CHPs (1,000-5,000 MW), too expensive and hard to build. Meanwhile, due to the technical-scientific progress, the medium-size power plants (up to 300 MW), are becoming more efficient and can be built in modules in short periods of time.

The distributed generation becomes more and more advantageous from the point of view of cost, efficiency and the impact on the environment. However, in the industrialized countries presently there is a centralized delivery of electric energy, whose efficiency and technical-economical advantages are well known. Other situation is in the thermal energy supply sector. Although the thermal networks appeared in some EU states at the end of the XIX-th century, until the energy crisis in 1973 the thermal energy supply to the urban localities was made mostly on the basis of autonomous heating systems. This situation is explained by several causes, such as:

- A strong influence of traditions;
- The consumers' tendency to independence;
- The lack of any new solutions from the state;
- The difficulty to modernize the heating systems in the conditions of old urban localities with narrow streets and intense traffic;
- The necessity to make huge investments in the centralized heating systems.

After the energy crisis in 1973 the situation became quite different. The main factor that convinced the consumer to change the common way of heating, promoting the development and the most propitious joining of the centralized and non-centralized heating systems, was the considerable raise of prices for the oil-products and other types of high-quality fuel used in the autonomous heating systems.

The energy crisis and, later, the ecological problems, raised to the governments of the developed countries the problem of energy security, energy conservation and the reduction of the energy sector impact on the environment. In this way, starting with the 70s of the XX-th century, in a series of countries there were taken legislative, economic and financial measures to encourage the development of centralized heat-supply systems on the basis of two principles which permit to reduce considerably the greenhouse gas emissions: (I) cogeneration and (II) the utilization of renewable energy sources, especially non-fossil fuel (domestic, agricultural and industrial wastes).

The PURPA Law [27], adopted in 1978 in the USA contains two basic principles:

1. The increase of the fuel utilization coefficient through stimulation of combined production of heat and power.
2. Advantageous conditions for application of innovation pointed to use the traditional and non-traditional energy sources as efficiently as possible.

At the end of the 80s, XX-th century, in the USA there were adopted programs that stipulated allocations of about 35 billion USD for energy cogeneration during the period 1980-2000 [28].

In 1978 the Japanese Bank for Development introduced a special financing system for combined energy generation, which includes long-run credits with a low rate of interest, provided to producers of machinery for CHPs.

In 1983 in Great Britain there was adopted the 'Law on Energy' [29], which promotes cogeneration. Special attention is paid to the cogeneration and fossil fuel utilization in Denmark. The 'Law on Thermal Energy Supply' [30] adopted in 1979 and amended in 1990 is largely supporting cogeneration. In the same year the Denmark Parliament adopted the Action Plan 'ENERGY 2000', which stipulated the transformation of all thermal plants having the capacity of 1 MW and more into CHPs, and a large-scale utilization of non-fossil fuel and biomass (straw, wood) and domestic waste in these power plants. These measures aimed to contribute to the reduction of GHG emissions by 20% given to 1988 by the year 2005. We maintain that the respective figures were achieved in the year 2000[31].

In France, Germany and other industrialized countries the electricity distribution companies are obliged by the Law to purchase, first of all, the cogenerated electricity.

Starting with 1990 the EU countries also began to stimulate the development of CHPs under the support of the "Joule-Thermie" program. In the framework of this program, there were financed 45 projects regarding the CHPs development. In 1993 there was set up the COGEN-EUROPE organization for cogeneration promotion, in which such countries Spain, Great Britain, Germany, France, Greece, the Netherlands and Portugal are members.

In 1997 in the EU there was proposed a strategy for the cogeneration development support through advantageous taxation conditions and the increase of funds allocations.

1.6.2. The evolution of the centralized heating systems

The level of the development and the actual situation of centralized heating systems in various countries depend on: the specific feature of their economy; the energy sector structure; fuel resources and other primary energy sources; weather conditions, etc.

In the Table 1.35 [30,32] there is presented the share of centralized systems in thermal energy supply of the residential and public sector (EU, 1990).

Table 1.35. *The share of centralized supply of heat for residential and public sectors (EU, 1990)*

Country	Share, %
Denmark	*47.4*
Finland	*44.0*
Sweden	*34.0*
Germany	*12.0*
France	*6.0*

The low rate of centralized heat supply in France is explained by the huge importance of the nuclear energy in the energy industry of the country. In the period 1990-2000 the share of centralized systems in these states was increasing. For instance, the share of centralized heating systems in Finland was of 46% in 1995.

The favorable elements for centralized heating systems development are the following:

-The cost of thermal energy not higher than in the case of autonomous heating;

-Faultless quality of service – The Danish population consider the connection to the thermal networks a thing as natural as the branching to the electric networks, telephone networks, water supply and sewage systems [30].

The following measures help to obtain a low cost of energy:

- cogeneration;
- cheap fuel consumption;
- the optimization and the rehabilitation of the systems.

I. The cogeneration in the industrialized countries

The cogeneration appeared in the industrial systems at the end of the XIX-th century, but it became widespread in the last quarter of the XX-th century, after the energy crisis in 1973. The cogeneration means the combined production of electric and thermal energies, using as fuel primarily natural gas. The power of a gas turbine is used to produce electricity, while the thermal energy of the gases evacuated through stacks can be used in various ways, inclusively for:

- the production of steam for process applications;
- the production of hot water in applications, such as for thermification and domestic-use water;
- the utilization of the emitted gas in drying applications;

– the production of cold using the refrigerating absorption plants.

The global efficiency of energy production for cogenerative power plants varies between 85-92% in comparison with the maximal efficiency of almost 55% for the power plants producing only electricity. In comparison with the separate production of the thermal and electricity, the quantity of the anticipated energy savings is about 20%. In the developed countries the cogenerating plants are usually placed close to the steam users, the costs linked to the transportation of thermal energy being reduced in this way. Due to high efficiency, the cogeneration is considered as an important way to diminish the GHG emissions.

Proceeding from the capacity and utilization types, the cogenerating power plants (CHPs) may be classified in the following categories:

– small capacity CHPs – 0.5-5 MW, based on Diesel engines and gas turbines producing thermal energy and cold for hospitals, swimming-pools, blocks of flats, offices, greenhouses, economic agents, economic units of low thermal and electric power;
– medium capacity CHPs – 5-45 MW, based on gas turbines used at chemical plants, refineries, factories, cellulose and paper factories, in food industry, etc.
– large capacity CHPs – 120-240 MW, used in the residual fuel and other large energy consumption industries.

Large CHPs are used in large centralized heating systems. For solid fuel burning steam turbine installations are used, for gas fuel – mixed gas\steam installations. We mention that the Esbierg CHP, with the highest efficiency all such plants in the world, won the prize of the American magazine "Electric Power International' 1994"[32]. In the Table 1.36 there are presented the specific features of some high-performance CHPs from Denmark and Germany:

Comparing the CHPs efficiencies, especially those consuming natural gas fuel (*Table 1.36*) with those from the Republic of Moldova (*Table 1.19*), we notice that although the global efficiency in both cases are close to each other, the electric output in the first case is 2-9 times higher.

In the last years, the small consumers of thermal energy, either industrial or from the residential sector prefer the small installations [36]. These work on natural gas and, in rare cases, on liquid, very expensive, fuel. These installations consist of the thermo-engine and the heat recuperator, which produce technological steam for the industrial consumption and hot water for heating and for domestic use.

In case of the capacities higher than 1 MW the gas turbines are usually used as thermo-engines, in the case of lower capacities – internal combustion engines, in most cases – Diesel engines.

In the Table 1.37 the specific features of these installations are presented.

Tabelul 1.37. *Caracteristicile instalațiilor cu cogenerare de puterea mică*

Indices / Installations	Gas turbine	Diesel engines
The electric capacity, MW	*0.5 -10.0*	*0.05 - 2.0*
The rate of heat supply	*0.3 - 0.7*	*0.5 - 1.0*
The electric output, %	*18 - 33*	*30 - 40*
The global efficiency, %	*75 - 90*	*85 - 90*

The share of cogeneration in the energy production of the industrial countries is various, however it has the decisive role in some of such countries. So, in Finland the share of the heat produced through cogeneration constitutes 75%, and over 30% in the case of electricity production [34]. In this country it is foreseen that, by the year 2010, the share of the CHP in the production of electricity will reach about 50% [35]. At present, in Denmark, about 50-80% [34,36] of the whole volume of electricity is produced through cogeneration, in the Netherlands-35%, in France-only 5% (in this country the share of nuclear power plants is high in the electricity production).

Table 1.36. *Technical features of some high-performance CHPs in some EU countries*

CHP	Type of fuel	Type of instalation	Capacity, MW		Efficiency, %	
			Electrical	Thermal	Electrical	Thermal
Esbierg, Denmark	Coal	ITA	*328*	*460*	*45.3*	*91.4*
Rostock, Germany	Coal	ITA	*509*	*300*	*42.5*	*62.5*
Berlin Mitte, Germany	Gas	ITGA	*380*	*380*	*47.3*	*89.2*

According to the studies done by the EU General Directorate for Energy and transport, during the period 2001-2010, for CHPs construction will be granted about Euro 28.0-49.7 bil., which will constitute 21.6-25.3% of the total allocations in the energy sector [38]. If the yearly average increase of the GDP is 3.6%, the capacity in the CHPs in the EU 15 countries will increase from 63.7 GW in 1996 to 103 GW in 2010. So the share of CHPs in the electricity production in the EU countries may reach 30%, with the highest possible contribution estimated to 40%.

II. The utilization of the non-fossil fuel in the centralized heating systems of thermal energy supply in the industrial countries

The following are considered as non-fossil fuel:

- Domestic waste,
- Industrial waste,
- Agricultural waste,
- Biomass resources,
- Firewood.

The centralized heating systems in the West Europe countries began to develop on the basis of domestic wastes combustion. At present, the production of solid domestic wastes in the EU countries is of 310 kg per capita yearly, with the average growth of about 1-3% per year [39]. At the beginning of the last decade of the last century, the share of gathered and combusted wastes was about 21.2%, in some countries this quantity is as it follows:

- Luxembourg - 70%, – Belgium - 50%,
- Denmark - 40%, – the Netherlands-30%,
- Germany - 22%, – France-22%.

The share of the combusted wastes has grown in the last decade. For instance, the share of the combusted wastes reached 55% in the year 2000 in Denmark. The domestic wastes are usually combusted in hot-water boilers or the plants, however lately CHPs have been constructed for this purpose.

If speaking about the industrial wastes, mainly that of the wood-processing industry is used. The crumbed branches received after woodcutting or orchards cleaning are combusted in the same installations. The firewood is used together with other solid fuel as well (coal, peat, straw, other biomass). The quantity of wood used in the energy sector in Denmark in 1997 was of about 700 thousand t.c.e. [40]. In this century, about 70 000 of the total 80 000 of small boilers based on solid fuel consumption, work on fire wood and various wooden wastes, having the share 75-79%.

The Mobjerg CHP (Denmark) with the electric capacity of 30 MW and the thermal of 67 MW works on peat, firewood and coal consumption. At the thermal power plants there are also used the husks of sunflower seeds – oil-press industry wastes. There are also used the wastes from the mills, malt production sections, and tinned-goods industry [41]. In Spain there is a CHP of 24 MW that works on husks of grapes. Straw is the most widely used of all farm wastes. For instance in Denmark there is more than 50 power plants (TPs and CHPs) that use straw as fuel.

A specific non-fossil type of fuel is the biogas obtained at the anaerobic fermentation of organic substances. The most widely used substances taken for this purpose are the animal dejection and the sewage mud. The biogas production from these substances has a double economical effect: The GHG diminution made thanks to the substitution of the fossil fuel, and the recuperation of the emissions of methane, ammonia and other gases – produced as a result of animal dejections decomposition in anaerobic conditions.

It is increasing the attention paid to the biomass resources with a high energy potential. So, in Germany, Austria and other EU countries the rapeseed cultivation becomes widespread. The methilic ether obtained from the rapeseed is delivered to more than 800 fuel stations in Germany [42]. There is 1.1 ton of oil obtained at each hectare of rapeseed; about one ton fuel with the features resembling to those of Diesel fuel and about 10 tones of biomass are obtained from this.

In the USA there are being made studies on the euphobiac species, in the sap of which (latex) the share of hydrocarbons reaches 1/3 of its mass. The yield capacity of these plants is of 6000 liters of hydrocarbon per hectare. Another widespread practice is the planting of forests for energy purposes (Denmark, Sweden etc.) [40].

III. The practice of the thermal energy supply systems optimization and rehabilitation in the EU countries

The optimization and rehabilitation of thermal energy supply systems has the following purposes:

– The diminution of thermal energy transportation and delivery losses and expenditures;
– The guarantee of the consumer service high quality;
– The harmonizing of the TPs and CHPs with the curves of electric and thermal demand.

These measures are guaranteed through:

– The placing of the thermal power sources in the geographical centers of thermal power consumption;
– The utilization in large urban localities of several heat sources, situated homogeneously and connected through ring-shaped networks;
– The application of the thermal load control equipment;
– The optimization of the thermal carrier parameters;
– The utilization of high-quality materials at thermal networks construction, at thermal stations assembly, etc.

For instance, Copenhagen, the capital of Denmark, is provided energy from 4 thermo-electricity plants and 7 power plants on wastes combustion, situated in all the regions of the city [30].

On its turn, the Parisian company for urban heating has 9 CHPs exploited in the rush-hours (on coal and residual fuel oil consumption), 3 TPs on wastes combustion and a geothermal plant, which consumes yearly: geothermal carrier-50%, coal-32%, and residual fuel oil-18% [43]. The centralized heating system of the municipality Grenoble (France), is supplied from 6 sources (including some thermal plants on wastes combustion), placed homogeneously around the city [44]. The homogenous location of the heat sources reduces the electricity consumption for the transportation of the thermal carrier, the heat losses in the network, increases the reliability of the system, providing steadily and qualitatively energy to the consumers.

The quantitative control, with the thermal carrier debit, of the heat flows according to the thermal load curve and the exterior temperature using high-capacity buffer-tanks, has arrange of advantages towards the qualitative control used in our country (with the thermal carrier temperature):

- It permits the reduction of the installed heating capacities, being replaced by the tank's capacity;
– It reduces the expenses for the electricity for the transportation of the thermal carrier;
– It permits an homogenous, high-performance TP boilers operation in optimal regime;
– It permits to the CHPs to operate in accordance with the electrical load curves.

In the West, once with the centralized heating systems development there appeared a series of modern machinery and technologies in the domain of thermal networks. These are assembled of the steel pipes preinsulated with polyurethane foam, protected on the exterior by a plastic tube, having an electronic system of moisture localization. The pipes are installed directly in the soil, without canals. For the secondary networks and couplings (diameter between 50-75 mm, temperature of 70-80 degrees Celsius) there are manufactured flexible cable-like pipes. The flexibility is achieved by using pliant materials: soft steel, copper, plastic, particularly PEX.

The losses of water are minimal; 0.5-2%. The heat losses become lower thanks to the thermo-insulating layer in the pipes and constitute in large networks 10-20%.

At the thermal stations there are used plate heat-exchangers, which besides the fact that they guarantee smaller heat losses, are advantageous as they occupy a 10 times smaller space than those used in our country, this fact allows to place them directly in the buildings so that there is no need to build special rooms.

IV. Non-conventional energy sources in the thermal energy supply sector

In the sector of the thermal power supply of the EU countries there is widespread the utilization of geothermal energy, biomass, solar energy and of the low-potential heat sources on the basis of heat pumps.

The geothermal energy is used for hot water supply, but also in balneo-therapeutic purposes, especially in France, Italy and Hungary.

The solar energy is used for water heating in the countries with warm climate, but also in such countries as Belgium, the Netherlands and Germany.

Special interest is paid to the utilization of low-potential heat resources (Temperature less than 40 degrees Celsius) based on the heat-pumps. These are installations that consume secondary energy (electric, mechanic or thermal) and raise to the necessary degree the potential of the energy-extracted form the ‘cold’ source. The coefficient of energy conversion, or the ratio between the usable energy obtained from the heat-pumps and the consumed energy, is 2-15, in dependence of the ‘high’ temperature difference. The obtained reduction of the fuel consumption is from some tens to some hundreds per cent.

As low-potential heat source it is used the atmospheric air, the waters from the rivers, lakes, seas, phreatic waters and the soil. It is also used the solar energy with its long-term accumulation in the soil. In the industrial installations there are used low temperature ‘worn-out’ thermal carriers, such as ventilation air, drying carriers, thermally processed products.

A widespread low-potential heat-source are the residual waters from the sewage systems of the industrial units and even of the cities. So, in the city Gothenburg (South Africa) the heat-pumps installed in the tanks with residual waters, with the thermal capacity of 165 MW, operate with the average rate of conversion 3.5, producing 2.16 PJ yearly; this permits to provide energy to about 150 thousand citizens [45].

The heat-pump is a refrigerating installation, which operates in a high-temperature regime. Consequently, one and the same installation may be used in the winter for heating and in the summer for conditioning. That’s why the autonomous installations are the most widespread.

The large capacity installations can be connected to the thermal networks. An interesting key might be the combined functioning of the CHPs. Being installed in regions far from the CHPs between the tour-return pipes, the heat-pumps reduce the temperature in the thoroughfare pipes between the CHPs and the heat-pumps, and reduce implicitly the heat losses between them. Moreover, the production of the return temperature increases the electric efficiency of the CHPs.

The heat-pumps became widespread in the industrialized countries. About 3 mil. of such installations worked in 1980 in the USA, more than 0.5 mil. in Japan, 150,000 in West Europe. Nevertheless, the heat-pumps weren’t solicited in the 80s, as a result of the renouncement to the most widespread refrigerating agent, R12, which turned-out to be ozone- active. Because of the above-mentioned fact, there appeared the necessity to assimilate new methods, so that in 1993 the number of the heat-pumps in the mentioned states exceeded 13 mil., and their yearly production exceeded 1 mil.. According to the prognosis given by the World Energy Council, the share of the heat-pumps in heating and hot water supply in the industrialized countries will be of 75% by the year 2020 [46].

The specific cost of a heat-pump installation with the capacity between 100-1,000 kW in the EU countries varies between 600-7,000 USD, the payback period of the majority of the installations doesn’t exceed 2 years.

1.7. Prospects for the energy sector development

1.7.1. The current situation of the national economy and the prognosis on the Republic of Moldova economic development

In 1990 the process of transition to the market economy in the Republic of Moldova began. The protraction of economic and social reforms, the unstable political situation, a frequent change of governments and other factors led to a catastrophic diminution of all economic and social indicators. So, in 1999, the GDP index abated with 66%, the consumption of primary energy resources – with 71%, the industrial production – with 68%, and the agricultural production – with 49% towards the year 1990. Only in the year 2000 the statistic data indicate the halt of the economic decline and even an insignificant growth of 1.9% of the GDP level.

In the Table 1.38 [47,48,49] there is presented the dynamics of the main macroeconomic indicators according to the designed “Medium-term strategy of the social-economic development of the Republic of Moldova”, elaborated by the Ministry of Economy, based on the Governmental Resolution no. 1107 of November 6,1998 regarding the “Strategy of social-economical development of the Republic of Moldova till the year 2005”, and on the data actualized by the Ministry of Economy in cooperation with other ministries, departments and research institutions, as well as in accordance with the “National strategy for sustainable development. Moldova XXI”.

Table 1.38. *The main macroeconomic indicators for the period 1995-2010*

Indices	Unit of measure	Real estimations		Pronostics	
		1995	2000	2005	2010
The GDP in real terms:	bil. MDL	*6.5*	*16.1*	*33.6*	*59.6*
– Towards the previous year	%	*98.6*	*101.9*	*106.5*	*105.0*
– Consumption prices, annual average towards the previous year	%	*130.0*	*131.0*	*107.0*	*105.0*
The yearly average rate of the national currency	MDL /1 $US	*4.5*	*12.4*	*17.0*	*23.0*
The commercial balance	mil. $US	*-95.0*	*-305.0*	*-165.0*	*-110.0*
The agricultural production towards the previous year	%	*101.9*	*97.0*	*102.0*	*105.0*
The industrial production towards the previous year	%	*96.1*	*107.7*	*107.0*	*106.0*
GDP, the structure of expenditures per chapters:	%	*100.0*	*100.0*	*100.0*	*100.0*
1. Agriculture	%	*29.3*	*24.5*	*21.4*	*20.8*
2. Industry		*25.0*	*17.5*	*20.2*	*21.3*
3. Wholesale and retail trade		*8.0*	*13.4*	*12.3*	*12.4*
4. Transport and communications		*5.1*	*9.0*	*9.7*	*9.8*
5. Constructions		*3.5*	*2.6*	*2.8*	*3.1*
6. Financial activities		*3.7*	*8.5*	*9.1*	*8.2*
7. Other branches		*16.3*	*18.0*	*19.5*	*20.9*
8. Intermediate services		*-2.2*	*-6.0*	*-7.3*	*-6.6*
9. Net taxation on the production and import		*11.4*	*12.4*	*12.3*	*10.1*

It is expected that the GDP will grow with 82% by 2010 towards the level in 2000 [48,49]. The structure of expenditures in chapters of the GDP will also change, as it follows: it will grow the share of the industrial sector, service sector and the gross formation of the permanent capital. At the same time, there will be reduced: the share of agriculture, the network taxation on the product and the value of the network export. In line with that the volume of the industrial production will double, and that of the agricultural production will grow with approximately 60%. By 2010 the volume of export will double towards the year 2000, the import volume will increase with only 34%.

In order to achieve these objectives and to improve the population standard of living, the national economy must be modernized, so that the necessary basis for its stabilization and relaunching could be created. The essence of the transformations consists in the creation of an independent, open economy, with an investment and legislative environment which would help to the transition of a prevalently agrarian society to the innovational economy, based on informational technologies, where the main elements are the advanced communicational and informational technologies, the intellectual property, the science and education as knowledge-generating branches and by these means the adherence to the process of the integration to the EU.

1.7.2. Prospective for the energy sector development

The energy sector of the Republic of Moldova aims to guarantee a continuous and efficient energy supply for the national economy and the social sphere, with a minimal impact on the environment.

The current situation in the energy sector is characterized as complicated, either from the economical point of view and that of energy efficiency and security of supply. Although in the last years the Government has made definite steps for the reformation of the energy sector, adopting a series of resolutions regarding the demonopolization, decentralization, the encouragement of the competition, the attraction of private investments, the crisis in the energy sector keeps worsening. The solution of this problem is possible only by carrying on of the economic reformation of this sector.

Although there does exist the legislative framework necessary for the reform promotion, the transition to the market economy goes on hardly because of the insufficient training of the managers and of the staff for activities in new historical conditions [50].

The energy sector is deeply affected by the disparity between the demand and offer, by the insufficiency of internal and external investments and by the ruined potential of production. The mission of the state in such a situation is to create and guarantee the necessary conditions for an efficient activity of the energy sector. So, the main objectives of the national energy policy are the following [51]:

- The promotion of an active policy of energy conservation to the consumer.
- The increase of the generating efficiency and of the electricity production capacity through the implementation of efficient technologies with the minimal impact on the environment.
- The implication of native energy resources, including the renewable ones, in the balance of consumption, in the case when these turn out to be economically competitive.
- The guarantee of state energy security, inclusively by the diversification of the types of fuel used on the territory of our country, of the sources and import means of the energy resources.
- The environment protection, inclusively through the respecting of the European norms and standards of the environment pollution.

I. The promotion of energy conservation policies

The notion of *energy conservation* comprises the organizational, scientific, practical, technical, economical and informational activities pointed to the rational utilization of energy resources in the process of extraction, production, processing, transportation, delivery and consumption of these, as well as to the attraction in the economical circuit of renewable energy sources [52].

The strategic objectives in the area of energy conservation in the Republic of Moldova are determined by the National strategy for a sustainable development and the Energy Strategy of the Republic of Moldova till the year 2010.

Since the period of transition to the market economy, characterized by a deep economical decline, in the Republic of Moldova there wasn't promoted a consistent policy on energy conservation, the cost of energy resources towards GDP constitutes about 30% (for instance, in Japan this share is 2.6%, in the USA – 4.1%, in Bulgaria – 9.8%, in România – 18%) [53], while energy and fuel consumption decreased three times. This situation is explained by:

- The increase of the share of the non-productive consumption (the consumption in the residential sector and social sector constitutes 46%).
- The promotion of an erroneous taxation policy, which didn't encourage the growth of the energy consumption efficiency.
- The lack of a national strategy, accompanied by the due legislative sets, which would support the actions of increasing the efficiency of energy consumption.

In the last years the cost of energy and energy resources consumed in the Republic of Moldova varies yearly between 300-500 mil. USD. One percent economized from this sum represents 3-5 mil. USD. It is known that in order to obtain 100 USD energy resources thrift, it is necessary to invest 30-40 USD. In these conditions, the 2-3% yearly reduction of the energy intensity will lead yearly to the saving of energy resources 12 mil. USD worth. Consequently, the value of the investments required for the increase of the energy efficiency is estimated to about 4 mil. USD.

So, the possibilities of the energy conservation are considerable. At this point the realization of an efficient policy in the domain of energy conservation would reduce the energy cost in the GDP with 10-12 mil. USD yearly. The encouragement of an efficient consumption in the residential sector could as well contribute to the increase of this figure. The experience of Japan gained after the energy crisis in 1973, when the GDP doubled in 8 years while the energy consumption grew only with 10%, proves the importance of the state in this activity.

The "Energy Strategy of the Republic of Moldova and the plan of actions till the year 2010" declares the promotion of the energy efficiency as an element of primary importance in the state energy policy [51]. According to this document the thematic objectives for the year 2010 are the following:

- The diminution of energy intensity in average with 2% yearly.
- The creation of the National Foundation for energy conservation and the utilization of the renewable energy sources.
- The elaboration and implementation of standards on energy consumption in the public buildings, transport, as well as for home-use apparatus.
- The utilization of the renewable energy sources which are economically competitive.

Despite the efforts made, the energy efficiency continued to decrease during the last years. Here are just some data that prove this thing:

- The energy intensity of the GDP constituted 1.889 kg. c.e. /1 USD in the year 2000; compare: in 1995 this figure was of 1.853 kg.

c.e. /1 USD (during 5 years the energy intensity of the GDP increased with 2%).

– The energy and fuel losses in the national economy by the year 2000 have also reached considerable values: electricity – 33.6%, thermal energy – 12.5%, natural gas – 9.6%, residual fuel oil – 3%; in 1995 these figures were, as it follows: electricity –35.7%, thermal energy – 13.7%, natural gas – 9.0%, residual fuel oil – 2%.

The above-mentioned data suggest some prior directions in the domain of energy and fuel conservation, which include the reduction of losses and the utilization of local energy resources, including the renewable ones.

In the energy sector of the country, the share of local energy resources in 1999, for instance, constituted 4.3% including: wooden wastes – 2.9%, agricultural wastes – 0.5%, hydroelectric plants – 0.9%) [53]. According to the estimations made by the specialists from the Institute of Energy of the Academy of Sciences from the Republic of Moldova, the local energy resources are much higher – about 11%.

The Government Action Program for the period 2001-2004 stipulates the increase of the GDP index with 7.5% yearly and that of the energy consumption with 2.5%, while the Energy strategy of the Republic of Moldova till the year 2010 stipulates the decrease of the energy intensity with about 2% till the year 2010. Theoretically, this would lead to the GDP doubling without the increase of electricity consumption. The implementation of the option would be, however, very difficult requiring huge efforts from the state.

The experience gained by the states that carry out efficiently such an activity for 20-30 years proves that it is difficult to offer an incentive to the consumer to allot his own funds, even if these do exist, in order to carry out the measures of energy efficiency including the cases when the results are known a priori (because the expected effect and the payback period have a long duration, 2-5 years, and the conversion of the economic effect into cash is problematic). This activity can be carried out with success only through the adoption of a set of legislative-normative acts corresponding to the economic-financial situation of the country.

According to the Draft of the "National program for energy conservation 2002-2010", for the accomplishment of the strategic objectives in the domain of energy conservation there are stipulated the following actions for increasing the efficiency of energy consumption at the beneficiaries, including [53]:

– The banking-financial insurance of the energy efficiency projects.
– The improvement of the fiscal-customs insurance of energy and fuel import.
– The metering of the energy flows in the framework of the industrial units.
– The accomplishment of the state expertise and of the energy audit regarding the efficiency of the energy resources utilization.
– The identification and promotion of economic-financial mechanisms in the energy conservation area.
– The supervision of the way the National Foundation for Energy Conservation sources are administered.
– The promotion of encouragement and penalty measures in the area of energy conservation.

The means and methods for the efficiency increase in the branch energy consumption are the following:

1. Industry:

– The compulsory accomplishment, once in 5 years, of the energy audit starting with the energy-intensive industrial units;
– The energy examination of the technologies and of the equipment;
– The elaboration of current and prospective plans for energy saving and for energy efficiency increase;
– The staff education and training in the spirit of energy conservation;
– The accomplishment of the energy examination of the rehabilitation projects;
– The modernization of the energy flows metering systems.

2. The industry of constructions and building materials:

– The utilization of local raw material in the production process;
– The elaboration of standards that would settle the thermal isolation features for the constructions, building materials, technologies used in the constructions;

- The endowment of the buildings with separate rooms and with adjustable systems of heating and water and gas supply;
- The elaboration of the basic decision framework for the existent buildings;
- The production of high-quality materials from the local raw material: non-burnt pressed bricks, concrete boards, artificial stone blocks with voids, and multi-layer concrete panels with glass wool layers.

3. Agriculture:

- A widespread agricultural wastes utilization: straw, wooden wastes, stems of sunflower, corn, tobacco etc. for thermal energy production;
- The favoring of electricity consumption in the period of low charge curve;
- The information and training of the staff involved in the energy resources utilization.

4. The residential sector:

- The launch of the national program of replacing the incandescent lamps with compact fluorescent ones (the realization of this project will have an economic effect of 8-10 mil. USD yearly);
- The promotion and encouragement of the import and local production of high energy efficiency energy appliances.

5. The public sector:

- The optimization of the energy carrier consumption norms;
- The establishment of yearly limits in the consumption of thermal and electricity and water;
- The elaboration of a taxation system which would encourage the efficient energy consumption;
- The modernization of illumination systems;
- The endowment of heating systems with adjustment elements;
- The implementation of buildings' thermal protection technologies;
- The information and training of the staff with the purpose of saving energy carriers.

At present, the activity of increasing the energy consumption efficiency in the Republic of Moldova is limited. In the period 2002-2003 the possible saving will be obtained mainly through organizational measures, which do not require major investments. According to the estimates for the period 2002-2003, the volume of required financing for the realization of energy efficiency is about 2.5 mil. USD yearly.

The financing sources needed for the realization of energy efficiency objectives are supposed to be obtained from:

- financial means accumulated through the application of economic penalties for the infringement of the legislative and regulation stipulations in the domain of energy and fuel consumption;
- the economic agents' financial means;
- the financial resources from the industrial units and from the Investment Fund;
- the resources of the National Fund for Energy Conservation;
- the investments from abroad and financial means obtained through the implementation of local projects financed from abroad.

II. The increase of energy generating efficiency and the implementation of efficient energy technologies with minimal impact on the environment

The increase of energy generating efficiency is a way of reduction of the primary energy resources consumption in our country. The limitation of fossil fuel consumption will have as a result the reduction of GHG and the prevention of the environment pollution.

To continue, we'll present some means of increase of the efficiency in the process of conversion of the primary energy to the secondary energy (electric and thermal) at the mixed and simple-type cycle thermo-electric power plants.

1. The simple cycle thermo-electric power plants:

- the increase of the combustion processes efficiency;
- the increase of the proper services efficiency;
- the utilization of secondary energy resources;
- the increase of the energy carrier parameters.

2. Mixed-cycle power plants:

- the implementation of efficient energy technologies – the combined thermodynamic cycle;

– the promotion of the thermal and electricity cogeneration.

The increase of the combustion processes efficiency. The increase of the combustion processes efficiency and the reduction of the expenditures for the thermal plants proper services are applicable to the thermal plants as well. Although the efficiency of the liquid and gas fuel combustion in the modern boilers' focuses is rather high, the application of such methods as the preliminary air heating, its ionization and the utilization of injectors with a high spraying degree, might increase this efficiency. By the combustion in the suspended layer of the solid fuel a high efficiency of the process results since the sulfur binding in the focus as well as its held back in the solid form of slag and ash happens. This method permits to combust industrial and urban wastes with an efficiency of almost 90%.

The increase of proper services efficiency. The auxiliary equipment for the service of the thermo-electric power plants and thermal plants in the Republic of Moldova consumes 3-12% of the generated energy. The use of the most modern machinery endowed with complex systems of automatic adjustment would permit to reduce considerably the energy consumption.

The utilization of secondary energy resources. The possibility to use the secondary energy resources resulted in the technological process usually appears in the industrial zones. So, for instance, the glass factory from Chisinau emits in the atmosphere combustion gases with the temperature of 500-700^{0}C. The installation at this factory of recuperating boilers would permit to save about 20 Gcal/h, that is equivalent to 20,000 t.c.e. Another important reserve of secondary energy are the residual waters from the industrial units and from the urban sewage systems. Having a low temperature, 20-40^{0}C, these may be a source of energy for the heat pumps. The heat pumps may be used in the autonomous thermal energy supply systems as well as in the centralized ones. In the Table 1.39. we present some specific features of the heat pumps in comparison with other sources of thermal energy.

As it may be seen in the Table, the heat pumps have the economical and ecological features resembling to those of the CHPs and are much superior to the other examined sources. As huge investments are required, it will be difficult to generalize the utilization of the heat pumps in our country's energy sector. The probability to exceed the share of 1% from the total energy consumption till the year 2010 is relatively small.

The increase of the energy carrier parameters. The thermal efficiency of steam turbine and gas turbine installations depends on the energy carrier parameters at the entrance and emergence from the turbine. The parameters at the entrance depend on the environment temperature, so that the increase of the installation's output may be achieved by the increase of the temperature and pressure of the energy carrier at the entrance. The most efficient gas turbine installations have at the entrance the temperature of about 1,400^{0}C and the pressure of 3.0 MPa, the steam turbine installations have, respectively, 650^{0}C and 30 MPa. The electric efficiency of the steam turbine installations reaches 45%, that of the gas turbine installations – 39%. The exit temperature of the gases from the gas turbine installations is 400-600^{0}C. In the combined installations with mixed gas/steam cycle these gases are led into the recovery boilers, which provide steam to the turbine. The electric efficiency of the mixed cycle may thus achieve 58%.

Table 1.39. *The specific fuel consumption and the direct GHG from different sources of thermal energy*

Source of energy		Unit of measure	Type of primary energy*	
			Natural gas	Coal
GHPs	Specific fuel consumption	kg.c.e./GJ	*19.0*	*27.9*
	Direct GHG emissions	kg/GJ	*31.5*	*79.7*
Autonomous TPs	Specific fuel consumption	kg.c.e./GJ	*35.9*	*42.7*
	Direct GHG emissions	kg/GJ	*59.6*	*122.1*
Heat pump	Specific fuel consumption	kg.c.e./GJ	*27.1*	*27.9*
	Direct GHG emissions	kg/GJ	*44.9*	*79.7*
Electrical heating boilers	Specific fuel consumption	kg.c.e./GJ	*94.8*	*97.5*
	Direct GHG emissions	kg/GJ	*157.4*	*279.0*

Table 1.40. *The economic and ecological indices of different types of CHPs based on gas fuel consumption*

Indices	Unit of measure	CHP with STI	CHPs with GTI+ HWB	CHPs with GSTI
Electric efficiency	%	36	30	48
Gross efficiency	%	82	80	85
Specific fuel consumption in the electricity production	kg c.e. / kWh	0.36	0.41	0.26
Specific fuel consumption in the heat production	kg c.e. / GJ	18.1	–	10.9
Fuel savings in comparison with separate production	%	24.1	23.6	36.6
Specific direct GEG in the electricity production	kg Direct GHG / kWh	0.60	0.68	0.42
The specific direct GEG in the heat production	kg Direct GHG / GJ	34.44	–	18.09

In the Table 1.40 there are presented the economic and ecological indices, estimated for the case when the natural gas combustion happens in the conditions close to the rated ones, for different types of thermification installations:

1) CHPs with steam turbine installations (STI);
2) CHPs with gas turbine or Diesel motors of internal combustion and hot water recuperating boilers (HWB);
3) The CHPs with mixed gas/steam turbine installations (GSTI).

As an example of CHP with steam turbine installations was taken the CHP -2 from Chisinau, with the electrical load of 80 MW and the thermal one of 220 MW; in the case of the second type of the installations with gas turbine and hot water recuperating boilers, for the gas turbines with the maximum power of 10 MW, the rate of electric output is relatively small (about 30%), in the case of the utilization of gas turbine installations with the power over 25 MW, the rate of electric output grows to 34-38%;

The third type of installations with mixed gas/steam turbine is characterized by the maximal electric output – over 48% (in our country there are no installations of the 2nd and 3rd types).

As it may be seen in the table, the rates of fuel economy in the first two cases are close to each other, in the case of mixed gas/steam turbine installations it is 1.5 times higher.

The implementation of efficient energy technologies – the combined thermodynamic cycle. With the purpose to improve the capacities of electricity production and to increase the energy efficiency at generation, in the "Energy strategy of the Republic of Moldova till the year 2010", approved by the Government's Resolution No. 360 of April 11, 2000, there is stipulated the construction of new capacities, the rehabilitation and extending of the existent thermal plants, as well as the transformation of the thermal plants into CHPs [51]. So, the rehabilitation options of the CHPs 1 and 2 from Chisinau and the CHP North foreseen for CHP-1 a capacity of 60 MW through the installation of 5 steam turbines with the capacity of 12 MW each one; the extension of the CHP-2 up to 585 MW capacity on the basis of 2 turbines type TP-115/125-130 and TF-110-2; the recovery extension of CHP-North up to 104 MW each on the basis of 2 steam turbines of 12 MW each one and 2 gas turbines of 40 MW. It is also projected the extension and rehabilitation of the hydroelectric power plant Costesti up to 24 MW. Considering the fact that one of the most important strategic points of the Republic of Moldova is the increase of the energy efficiency and the protection of the environment, the development of new production capacities is supposed to be accomplished through the implementation of energy technologies with a minimal impact on the environment.

The promotion of electric and thermal energy cogeneration. The development of the sources of the combined thermal and electricity production by cogeneration on the basis of the thermification cycles at the existent thermal plants and the utilization of mixed gas/steam turbine installations will allow to increase the used part of fuel primary energy to 80-92%. In case of cogeneration, for thermal energy supply is based on the recuperated heat from the process of electricity production. This permits to save up to 20-400 of fuel in comparison with the separate production of the same quantities of thermal and electricity. With this purpose it is reasonable to build new sources of combined energy production, on the basis of small and medium size mixed gas/steam installations, whose efficiency of fuel utilization would reach 50-56%.

According to the assessments of the specialists from the Institute of Energy of the Academy of Science of Moldova, the total electric capacity of the mixed gas/steam turbine installations, which might be built on the territory of the Republic of Moldova on the basis of the existent thermal plants, can reach in the year 2010 the rate of 930 MW and the thermal capacity – 730 MW (*Appendix 1.14*). The total investments required are estimated to 452 mil. USD (at the specific cost of 1 kW of about 530 USD).

More favorable conditions for co-generating installations there are especially in the urban localities and industrial units, the fact explained by a higher rate of energy consumption by the residential and industrial sectors.

In order to appreciate the real possibilities of cogeneration in these sectors, on the basis of the "Energy strategy of the Republic of Moldova till the year 2010", the "National strategy for sustainable development, Moldova XXI", "Strategic orientations of social-economical development in the Republic of Moldova till the year 2005" and the existent legislative framework, there was determined the demand of these sectors for thermal energy delivered through centralized heating systems, for the period till the year 2010. The thermal energy demand in the residential sector was estimated taking into consideration the following conditions:

- the population of the country, without the localities from the left bank of the Nistru, will be of about 3.6 million in the year 2010 [49];
- the share of urban population will constitute 46% [49];
- the share of centralized heating in the urban localities is about 77% [49];
- the share of hot water for domestic use is 60% [49];
- the rate of the thermal energy consumption for heating constitutes 6.9 GJ per capita per year [54];
- the rate of thermal energy consumption for domestic-use hot water supply is 8.15 GJ per capita per year [54];
- the share of public consumption is about 25% [54].

The demand for thermal energy will be 19.43 PJ/year. The total energy losses in the thermal networks were considered to be about 15%. Thus, the total thermal energy consumption in the centralized systems will be of 21.12 PJ/year. Accepting the coefficient of thermal production capacity use equal to 0.5, required thermal will be of 1050 MW.

The conditions for the estimation of the thermal capacity required by the industrial construction sectors are follows:

- The share of the electricity consumption in the industrial sector constitutes 23% of the overall electricity consumption;
- The share of the thermal energy consumption in the industrial sector constitutes 58%;
- The share of electricity consumption in the construction sector is 6% [According to the Ministry of Economy];
- The share of thermal energy consumption in the constructions sector is 17%.

Under these conditions the thermal power consumption in industry and constructions will be of 12.41 PJ per year. After having estimated the diminution of the consumption to 20%, as a result of energy conservation measures, and the thermal network of 5%, the obtained quantity of required thermal power is 10.42 PJ per year. Considering the coefficient of capacity use of 0.6, the thermal capacity requested will be 500 MW.

Thus by the year 2010 the total possible thermal capacity of the cogeneration facilities in our country will be of 1,600 MW. Considering that the average ratio of thermification is 0.6, we obtain the potential electric capacity of the cogeneration installations – 960 MW. With the rate of electric capacity use of 0.75, the yearly electricity production will be 6.3 TWh, that is 76% from the consumption projected for the year 2010 (8.3 TWh). If the share of the utmost thermal load in the residential sector is 15%, the total quantity of thermal power potentially produced through cogeneration is estimated to 26.44 PJ.

Since the cogeneration in Moldova may not cover the aggregate demand for energy by the year 2010, the necessity to introduce new electricity generation capacities may occur. Further on, some specific features of the up-to-date thermal plants will be presented (*Table 1.41*).

Table 1.41. Features of up-to-date power plants

Indices \ Type of the power plant	STI with condensation			GTI	GSTI	NPP
	Type of fuel used					
	coal	fuel oil	gas	gas	gas	nuclear
Specific investments, USD/kW*	*1,200*	*900*	*650*	*300*	*600*	*1,780*
Gross efficiency, %*	*42*	*43*	*43*	*35*	*53*	*30*
Own consumption,*	*9.0*	*7.3*	*6.0*	*3.0*	*5.0*	–
Net efficiency, %*	*38.2*	*39.9*	*40.4*	*34.0*	*50.4*	–
Specific fuel consumption, kg. c.e.\kWh produced	*0.322*	*0.309*	*0.304*	*0.362*	*0.244*	–
Losses related to transportation, %	*10*	*10*	*10*	*10*	*10*	–
Specific fuel consumption, kg. c.e.\kWh consumed	*0.358*	*0.343*	*0.338*	*0.403*	*0.271*	–
Direct GHG, kg/kWh consumed	*1.073*	*0.775*	*0.588*	*0.700*	*0.472*	–

* The average specific costs of the thermal plants and own consumption is given according to [55,56] the data on the average efficiencies of the modern facilities of large and medium capacities are based on the information given by the producers.

Conclusions:

– The minimal specific emissions are observed for the installations with the mixed cycle gas-steam (GSTI). The specific cost of GSTI is equal to that for the classical gas-fire thermal plants, however the specific fuel and water consumption is lower; consequently the cost of the generated energy will be lower. While introducing new electricity generating units, inclusively those with cogeneration, in our country, we should rather prefer the mixed gas\steam installations since these have better economic and ecological parameters.

- The highest specific emissions are being observed in the traditional steam-turbine installations, especially those using coal as fuel. Considering the gas-fired thermal plants high emissions are recorded for the gas-turbine installations, this can be explained by high fuel consumption. These specific features must be taken into consideration since the investments, compared to other power stations, are 2-6 times smaller.

- In the case of nuclear plants the emission of greenhouse gases is completely missing, but such kind of plants require huge investments - in dependence of machinery, location, etc. The specific cost of installed capacity varies from $1,200\kW to $2,900\kW [55].

III. The implication of renewable energy sources in the consumption balance

The renewable energy sources (RES) comprise: the solar (thermal and photovoltaic PV), wind energy, hydraulic, biomass and geothermal energies.

The solar energy. The utilization of the solar energy began in the Republic of Moldova at the end of the 50s last century [57-62]. New solar thermal installations were elaborated, set up and tested in that period. But a large-scale implementation of those installations wasn't accomplished, in absence of a consistent policy of RES promotion. The actions of solar installations' implementation in our country resumed in the period 1982-1987, since 1999 till nowadays solar installations for water heating have been produced in Moldova ("Incomaş" JSC). 140 installations with solar collectors having the surface of 1.4 and 2.2 square meters have already been implemented.

Due to the fact that the whole population of Moldova has access to public electric networks, the photovoltaic solar energy has a relatively limited area of utilization in our country; only few experimental photovoltaic installations for water pumping [63], communication systems and meteorological stations have been implemented. These installations may have a relatively limited area of utilization in future as well: small irrigation, low electricity consumption rural consumers, dispersed on the territory, anti-hail protection stations, sylvan enclosures etc.

Wind energy. According to the statistical data 6,208 windmills have been registered on the territory of the Republic of Moldova in 1901. Many of them have been in operation during the inter-war period as well. In the 50s of the XXth century, in our republic have been set over 350 mechanical wind- power installations, meant to be used exclusively for pumping water systems and for fodder processing in the collective agricultural farms. These have worked efficiently until the years 1960-1964 when they were replaced with cheaper and more convenient electric systems. Presently only several experimental wind-power installations are in operation in our republic, these are used to generate electric power in autonomous systems. It is supposed that the interest towards wind-power energy will increase in the nearest future.

Hydroelectricity. The kinetic water energy is relatively poorly used in Moldova: there are only one 48 MW HEP on the Nistru River, and another one of 16 MW HEP-Costesti on the river Prut. At present a special interest is paid to small rivers. Unlike large HEPs, the smaller ones on the small rivers are not of a great interest for large companies, however these may be of great use for small farms.

The HEPs with a capacity of 5 MW do not damage the environment as these are complementary to the traditional systems. In many cases the small rivers may provide an essential energy supply to the agriculture (small irrigation) and to the small-scale industry (of canned goods, wine, sugar etc.); at the same time this is an advantage for the public electric networks, especially in the rush-hours.

Unlike large HEPs, that require tanks for water accumulation, complex control systems, a great volume of organizational work and maintenance, the small HEPs are easier to handle and have the payback period of one year at the most.

Biogas energy. Since 1957, experience in obtaining biogas from organic remainders has been gained in the Republic of Moldova. For instance, at the Technical University of Moldova there have been elaborated and tested new biogas installations for processing the liquid organic remainders with the fixed micro flora. The most representative data were obtained at the satellite-stations for processing the animal breeding remainders and the industrial water used to produce wine, sugar, spirits, fodder dregs etc.

At present only five plants of cleaning the used up water are provided with installations for mud anaerobic processing and for biogas recuperation: Chişinău, Tiraspol, Bălţi, Tighina, and Cupcini. For the time being none of these uses the available fermentators.

The geothermal energy. In the South of Moldova (Cahul County) there are resources of geothermal energy with the temperature of 40-100 degrees Celsius, that may be used in greenhouse farms and in balneotherapy.

In accordance with the Energy Strategy of the Republic of Moldova, in our country it is expected to create conditions in order to meet the consumers demand for electric and thermal energy through a large scale utilization of renewable energy sources.

Since at present a utilization of domestic natural energy resources is not practiced, the identification of national potential regarding a large scale implementation of RES is an activity of major importance for the state.

As it has been mentioned, the fossil fuel in the energy balance may be partially replaced by renewable sources. According to some projections, the share of RES in the total energy consumption might constitute 10%.

By the year 2010 the total consumption of fuel and electric power will constitute 6.5 mil. t.c.e., from which the RES will cover 0.65 mil. t.c.e., including:

– Wind power energy-130 thousand t.c.e.
– Thermal solar energy – 120 thousand t.c.e.
– Photovoltaic solar energy 13 thousand t.c.e.
– Biogas – 62 thousand t.c.e.
– Wood and agricultural residues – 260 thousand t.c.e.
– Hydroelectricity – 65 thousand t.c.e.

For the realization of this forecast there is required political will in all governmental spheres and a well-coordinated effort to mobilize the financial, human, technical and technological state resources.

At present in Moldova doesn't exist a well-defined state strategy regarding the RES implementation, resembling to that of the EU states [66]. The already existing documents on the RES exploitation in the best majority of the cases have no institutional, scientific and financial support. The principles stipulated in different documents are in discordance with each other. Unfortunately, the National Program of RES Implementation, the draft of which was elaborated by the Institute of Energy of the Academy of Science in 1997, was not adopted yet.

Presently, this program is being put up-to-date, on the initiative of the Ministry of Energy and the Ministry of Economy.

The National Program for the RES Implementation will give priority to:

– Solar energy installations for water heating (in the rural regions), fruit and vegetables drying.
– Autonomous photovoltaic installations for supplying the dispersed on the territory with low demand consumers.
– Large connected to the network wind-power generating units with the installed capacity more than 500 kW.
– Small wind-power generating units of 1-5 kW for mechanical water pumping, and units of 1-10 kW for thermal energy generating.
– Biogas installations for processing then liquid organic dejections, the mud proceeded from utilized water cleaning, the water utilized in the food industry, using the gas for cogeneration.
– Hydraulic turbines as Francis, which use the energy of the small rivers.

IV. Ensuring the security of supply

The Republic of Moldova incurs a great risk regarding the energy supply, as it is nowadays totally dependent on the import of energy resources. It is well known that a higher degree of security requires higher costs. In the present economical situation – when the society can't pay for the current energy consumption, not speaking of an optimum level of energy security – the Republic of Moldova is forced to accept a high degree of insecurity. The country will remain dependent on the import of electricity for a long term.

The energy security can be guaranteed through the diversification of the electricity and oil products import sources, through the development of own capacities of electric power generation, as well as through making strategic fuel reserves [51].

In this respect, the main measures will be pointed to the privatization of the current assets of the companies responsible for providing the consumer with electricity; the building of the oil station in Giurgiulesti and of the adherent network; the possible participation in the construction of a new branch of the oil-pipe Odesa-Brodi (Ukraine), with the view to construct a domestic oil- refinery (the actual demand for oil and oil products in our country is estimated to 5-6 mil. tones) [67]. The increase of the working-efficiency of the railway junction in the Western border; the formation of an institutional and legislative-normative frame regarding the public acquisition of energy resources; the creation of strategic reserves of energy resources; the continuation of native resources prospecting, as well as the exploitation of the identified sources that turn out to be competitive.

For a good electric power supply, there is required a new electricity production capacity of the country. With this regard, the construction of new thermal plants of 100-300 MW each one is aimed, as well as the increase of the existent thermal plants capacities. Since the regional market offers nowadays electricity at a relatively low price, there becomes of primary importance the formation of a competitive home-market of the electric power, to the contribution to form a functional and transparent regional market. With this regard there is the necessity to reshape the electric transport network and the interconnections aimed to increase its capacity for energy import and transit.

V. Preoccupations regarding the environment protection

About 50% of the GHG emission and harmful substances that pollute the environment proceed from the energy sector as a result of the national economical activity. In the majority of the cases, the pollution of the environment is within the allowable limits, with the exception of some cases at the MTPP, the Thermal Plant South Chişinău and certain vehicles that consume diesel oil and petrol.

Taking into consideration the fact that the requirements on the environment protection become more rigid all over the world, there is the necessity to make definite steps to respect the allowable limits of air pollution, since the Republic of Moldova has signed several international agreements regarding the respecting of the standards on harmful substances emission.

In the process of the reshaping the energy sector, which is already on-going, the ecological problems that have been lately considered unsolvable because of lack of financing will be solved as well. Once that the thermal plants are privatized, the state will have to observe the respecting of environment protection requirements applied to the polluting plants of the country.

Since the new power plants that will be built in future will work prevalently on natural gases, it is expected that by the year 2010 there will exist no problems connected with the pollution of the environment, caused by the electric power generating sources.

The launch and the implementation of the national program of energy conservation, in its turn, will seriously contribute to the diminution of GHG and other harmful substances. The main means of diminution of the energy sector impact on the environment are the following:

- The substitution of fossil fuel with natural gas and LPG that are less pollutant, for vehicles as well.
- The elaboration and implementation of state ecological standards and normative at the level of the European ones, regarding the reduction of GHG and harmful substances, including the power plants and the means of transport.
- The elaboration and implementation of economical mechanisms for environment protection in the energy sector.

1.7.3. The forecast of the electricity and heat demand till the year 2010

I. Electricity

It is expected that by the year 2010 the electricity demand in the Republic of Moldova will be met from the native power plants as well as from import.

In the Table 1.42 [7,51] there are presented some information regarding the energy balance in the period till the year 2010 in the Republic of Moldova (without the territory from the left bank of the Nistru) with references to the data received from the Ministry of Economy, the energy balance of the country (data from the Department of Statistics and Sociology) and the Energy Strategy of the Republic of Moldova till the year 2010.

According to these estimations, the deficit of electricity will be of 7.3 bil. kWh by the year 2010. At present the installed capacity of the electric energy sources from the right bank of the Nistru is 335 MW, the power deficit is 608 MW. In order to cover the stipulated consumption of 6.4 bil. kWh, this deficit will achieve approximately 1000 MW by the year 2005, and respectively, 1580 MW by the year 2010. The deficit can be set off by building on the right bank of the Nistru of electricity sources, by delivering electricity from the MTPP, as well as in combination with partial import of electricity.

According to the estimations made by the Institute of Energy of the Academy of Sciences of Moldova, the full coverage of power deficit on the right bank of the Nistru on the account of new energy sources building and extending the existing ones, requires major investments of capital, that might reach the sum of 950-1,266 mil. USD by the year 2010, considering the price for 1 kW of installed capacity to be 600-800 USD.

Table 1.42. *The main power and economic indices (the right bank of the river Nistru, 1995-2010)*

Indices	Unit of measure	Real estimations		Pronostics	
		1995	2000	2005	2010
GDP	USD mil.	*1442*	*1146*	*1660*	*2443*
Population	mil. inhabitants	*3.675*	*3.640*	*3.610*	*3.600*
Energy resources consumption	mil. t.c.e.	*5.531*	*3.820*	*6.400*	*9.300*
Electric power consumption	bil. kWh	*5.373*	*3.380*	*6.000*	*8.600*
Energy intensity	kg.c.e. / $US	*3.836*	*2.960*	*2.500*	*2.300*
Electric intensity	kWh / $US	*3.730*	*2.620*	*3.855*	*3.807*
Energy resources consumption per capita	t.c.e./per capita	*1.510*	*1.050*	*1.773*	*2.583*
Electricity consumption per capita	MWh/per capita	*1.430*	*0.930*	*1.662*	*2.389*
Electricity produced by native sources	bil. kWh	*1.066*	*1.106*	*1.470*	*1.470*
Energy delivered in the network, including own consumption of 10%	bil. kWh	*0.960*	*0.995*	*1.323*	*1.323*
Electricity deficit	bil. kWh	*4.413*	*3.234*	*4.667*	*7.277*
Available power required (at T_{max} = 5600 h/year)	MW	*959*	*755*	*1071*	*1535*
The power required to meet own consumption (+10%)	MW	*95.9*	*75.5*	*107*	*153.5*
Reserve of power required in the case of an accident (+15%)	MW	*143.8*	*113.2*	*160.6*	*230.2*
Installed capacity required	MW	*1,198.7*	*943.7*	*1,338.6*	*1,918.7*
Available capacity	MW	*338.4*	*335.2*	*335.2*	*335.2*
Power deficit	MW	*860.3*	*608.5*	*1,003.4*	*1,583.5*

II. Thermal energy

In order to estimate the total domestic demand for thermal energy the following were taken into consideration: the demand of the consumers from the residential sector, public sector, the industrial sector and the constructions sector. This consumption has been considered proportional to the evolution dynamics of the respective branches according to the data given by the Ministry of Energy. The losses and expenses for thermal energy transport in the year 2000 were estimated according to the "Energy Balance of the Republic of Moldova 2000" [7], in prospect – with some reductions.

In these conditions, by the year 2010 the total consumption of thermal energy in the residential sector will be of 21.1 PJ per year, in industry and constructions- 12.4 PJ per year. Considering that the coefficient of the thermal capacities use is about 0.5, the total thermal capacity required will be 1,600 MW, while the real aggregate demand for thermal energy in our country has been estimated to 26.4 PJ.

In the Table 1.43 there is presented the level of centralized production of thermal energy in the year 2000 and the forecast of the demand for thermal energy in the Republic of Moldova in the period 2005-2010.

Table 1.43. *Development of centralized heating systems*

Indices		Real estimations	Pronostics	
		2000	2005	2010
The need for thermal energy, PJ		*26.2*	*29.7*	*32.8*
Transport losses, %		*13*	*12*	*10*
Demand for thermal energy, PJ		*23.2*	*26.5*	*29.8*
Real production of thermal energy, PJ		*12.8*	*19.3*	*26.4*
Real production of thermal energy, %		*49*	*65*	*80*
Of that, %:	CHP	*51.5*	*67.4*	*68.6*
	TPs based on wastes	*0.0*	*1.0*	*2.2*
	TPs based on fossil fuels	*48.5*	*31.3*	*28.7*
	Heat pumps	*0.0*	*0.2*	*0.5*

As it is seen the Table, in the year 2000 there was produced less than a half of the demand of the thermal energy. Till the year 2010 there is projected the 80% meet of the demand. At the same time, it is stipulated the diminution of thermal energy production by thermal plants operating on fossil fuel and the increase of the share of cogeneration installations, as well as the large scale energy valorization of urban wastes and the utilization for the first time of the heat pumps.

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2. THE TRANSPORT SECTOR

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2.1. The structure of the transport sector

The transport sector of the Republic of Moldova has the following structure:

- – Road transportation;
- – Railway transportation;
- – Air transportation;
- – Naval transportation.

The share of different types of transport, in terms of utilization by destination is disproportional: over 86% - the road transportation, 12% - the railway transportation, and only 2% - other types of transport (air and naval transportation).

I. The road transport sector

According to the information presented by the Road Police Direction of the Ministry of Intern Affairs of the Republic of Moldova, in the period 1995-2000 the number of road transport units in our country was constantly increasing (with the exception of the motorcycle transport, trucks, and the units of special road transport and non-road mobile sources and machinery, whose number in 1991 was decreasing) (*Table 2.1*).

Since the car park in the Republic of Moldova was increasing in the period 1995-2000, there might be forecasted an increase in the fuel consumption. However, this increase is not reflected in the official sources [1] *(Annex 2.1)*. It is considered that the data presented in the official statistics referring to the fuel consumption in the road transport sector does not reflect the real situation, because of the imperfect methods of fuel import accounting, and also, due to shirking from accounting (illicit imports). So, according to the assessment performed by the specialists from the Ministry of Transport and Communications, in the period of 1994-2000 in our country there were illegally imported about one million tons of fuel yearly.

II. The railway transport sector

In the period of transition to market economy, the railway transport was affected by serious financial problems. Because of the lack of money for the maintenance and reparation of the rolling stock, in the period of 1990-2000 the number of the railway transport units considerably decreased: the railway engine force – about 4 times and that of the Diesel trains – 2 times *(Annex 2.2)*.

According to the Department of Statistics and Sociology of the Republic of Moldova [1], in the period of 1990-2000 the fuel consumption by the Moldovan Railways decreased 5.7 times *(Figure 2.1)* as a result of the drastic reduction of the cargo and passenger transport, because of the difficult economical situation.

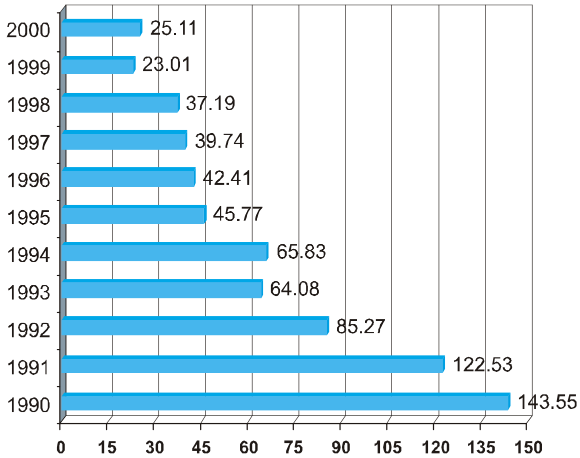

Figure 2.1. *The trend of Diesel fuel consumption in the railway transport sector, thousand tons (1990-2000)*

III.The naval and air transport sector

The share of the naval and air transport was and will be insignificant in the Republic of Moldova. The difficult situation of the national economy

Table 2.1. *The structure of the road transport, transport units (1990-2000)*

Types of transport sector / Year	1990	1992	1994	1996	1998	2000
Total of transport units, including:	**520,300**	**442,915**	**423,450**	**402,511**	**425,567**	**440,610**
Motorcycle transport units	*200,635*	*178,704*	*159,796*	*138,774*	*115,735*	*91,356*
Road transport units, including:	*319,665*	*276,540*	*263,654*	*263,737*	*309,832*	*322,691*
Trucks	77,231	67,033	67,045	63,008	61,942	61,689
Buses	11,847	10,290	10,759	10,820	13,191	14,023
Passenger cars	213,020	186,888	173,971	179,212	225,050	241,291
Other transport units	17,567	12,329	11,879	10,697	9,649	5,688

typical to the period of 1990-2000 had a hard impact on these types of transport as well. So, in the year 2000, the fuel consumption in the internal naval and air transport decreased 1.7 times and, respectively, 4 times by 1990 *(Annex 2.3).*

2.2. The assessment of the GHG emissions proceeded from the transport sector

2.2.1. Methodological aspects

The assessment of the direct (CO_2, CH_4, N_2O) and indirect (NO_x, CO, NMVOC) greenhouse gases emissions proceeding from the fuel combustion in the transport sector during 1990-2000 was accomplished on the basis of the guide worked out by the Inter-governmental Panel for Climate Change (IPCC, 1996) [2]. In accordance with the IPCC recommendations, in order to express the total direct GHG emissions as aggregated emissions expressed in CO_2 equivalent, there was applied the global warming potential for a period of 100 years [2].

The emissions of the greenhouse gases were estimated on the basis of primary data on fuel consumption, provided by the Department of Statistics and Sociology, as well as in accordance with the data offered by the Customs Department of the Republic of Moldova, the Moldovan-Russian Joint-Stock Company (JSC) "Moldova-Gaz", the Ministry of Agriculture and Food Industry from the Republic of Moldova, the Road Police Direction, the Great General-Staff of the National Army and the State Administration of the Civil Aviation from the Republic of Moldova. The assessment of the emissions from fuel combustion at the transport units in the localities on the left bank of the river Nistru for the period 1990-2000 was not accomplished because of lack of data.

For the assessment emission coefficients were used, expressed in grams of GHG emissions per kg of fuel consumed *(Annex 2.4).*

2.2.2. The assessment of the direct GHG emissions

The total direct greenhouse gas emissions assessed through the global warming potential for 100 years, expressed in CO_2 equivalent, proceeded from the transport sector, were estimated for 1990, 1995 and 2000 to amount to 5555.64 Gg, 2110.56 Gg and, respectively, 1110.37 Gg. In the period 1990-2000 the total direct greenhouse gas emissions from the transport sector decreased with about 80% to level of 1990, this period being characterized by a continuous tendency of this type of emissions reduction.

The direct GHG emissions, expressed in CO_2 equivalent, and resulted from the utilization of all types of fuel in the transport sector, proceeded mainly from the combustion of gasoline, Diesel oil and aviation gasoline *(Figure 2.2).* In the following years the share decreased of emissions deriving from the combustion of LPG, gasoline and Diesel oil, and share of emissions from the combustion of the LNG and aviation gasoline considerably increased.

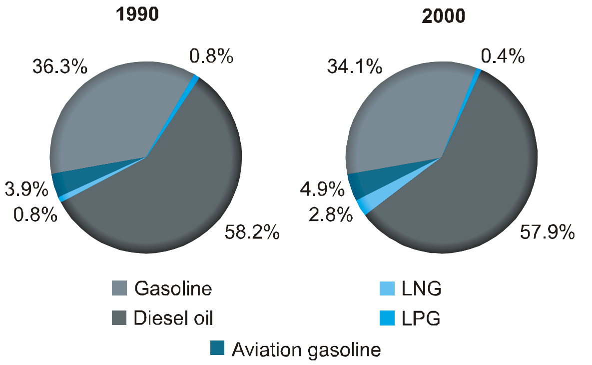

Figure 2.2. *The share of different types of fuel in the structure of total direct GHG emissions proceeded from the transport sector (the years 1990 and 2000)*

As a result of the national economy decline and of the general decrease of fuel consumption, the total emissions from their combustion in the transport sector decreased 5 times, including: the GHG emissions from the road transport – 5 times, from the railway transport – 5.7 times, from the air transport – 4 times, and from the naval transport – 1.7 times *(Table 2.2).*

In 1990, the share of the road transport in the total direct GHG emissions proceeded from the transport sector, expressed in CO_2 equivalent accounted for 87.77%, that of the railway transport – for 8.31%, that of the air transport – for 3.91% and that of the naval transport, respectively, - for only 0.004%.

In the following period a minor increases occurred of the air transport and of the naval transport, and the share of the railway transport decreased, so that

Table 2.2. *The dynamics of the direct GHG emissions resulted from the transport sector, Gg CO_2 equivalent (1990-2000)*

Year	Road	Railway	Air	Naval	Total
1990	*4,876.4*	*461.8*	*217.3*	*0.25*	5,555.6
1991	*4,865.4*	*394.2*	*232.7*	*0.24*	5,492.5
1992	*3,085.0*	*274.3*	*96.2*	*0.21*	3,455.7
1993	*2,110.8*	*206.2*	*32.1*	*0.24*	2,379.3
1994	*1,728.0*	*211.8*	*37.8*	*0.19*	1,977.7
1995	*1,921.2*	*147.3*	*41.9*	*0.18*	2,110.6
1996	*1,719.8*	*136.4*	*65.9*	*0.20*	1,922.3
1997	*1,831.1*	*127.8*	*75.6*	*0.22*	2,034.8
1998	*1,459.8*	*119.7*	*72.5*	*0.14*	1,652.0
1999	*917.7*	*74.0*	*47.3*	*0.17*	1,039.2
2000	*975.6*	*80.8*	*53.9*	*0.15*	1,110.4

the share of the road transport in the total GHG emissions proceeded from the transport sector in 2000 remained practically the same as that registered in the reference year, and accounted for 87.9%, that of the railway transport – for 7.3%, that of the air transport – for 4.9%, and that of the naval transport – for 0.013%.

2.2.3. The assessment of the indirect GHG emissions

In the period 1990-2000 there were registered considerable reductions of the indirect greenhouse gases emissions from the fuel combustion in the transport sector: the NO_x emissions decreased by 5.5 times, and those of CO and NMVOC – by 5.4 times *(Table 2.3)*. This situation was caused by the economical recession and, respectively, by the reduction of the general fuel consumption in this sector.

Tabelul 2. 3. *Dinamica emisiilor de GES indirect rezultate din arderea combustibililor în sectorul transport, Gg (1990-2000)*

Year	NO_x	CO	NMVOC
1990	*83.24*	*286.48*	*37.23*
1991	*80.42*	*282.45*	*36.33*
1992	*53.12*	*260.99*	*21.59*
1993	*36.78*	*100.87*	*14.02*
1994	*29.74*	*94.22*	*12.49*
1995	*30.41*	*120.39*	*15.12*
1996	*28.49*	*97.40*	*12.60*
1997	*18.76*	*115.09*	*14.61*
1998	*22.98*	*92.04*	*11.82*
1999	*14.57*	*49.80*	*6.88*
2000	*15.09*	*53.22*	*6.90*

a. NO_x emissions

In 1990 the total NO_x emissions from fuel combustion in the transport sector were estimated to about 83.24 Gg. In 1990 the emissions of gases of the NO_x group in the transport sector, derived from the combustion of: gasoline – accounted for 26.26%, Diesel oil – for 71.43%, the LNG – for 0.83%, the LPG – 0.45% and the aviation gasoline – for 1.04% *(Annex 2.6)*.

In 2000 the share of NO_x emissions changed, accounting for 26.66% from the gasoline combu-stion, 68.40% from the Diesel oil combustion, 3.21% from the LNG combustion, 0.32% from the LPG combustion and, respectively, 1.42% from the aviation gasoline combustion. In 2000 the NO_x emissions were estimated to about 18% from the 1990 volume.

b. CO emissions

The CO emissions from the transport sector in 1990 amounted to 286.48 Gg *(Annex 2.7)*. In 1990 these emissions derived from the combustion of: gasoline – accounted for 90.28%, Diesel oil – for 9.00%, LNG – for 0.12%, LPG – for 0.47%, and aviation gasoline – for 0.13%.

The share of gasoline and LPG in the CO emissions decreased in 2000 to 89.46% and, respectively, to 0.31%, while that of the Diesel oil, LNG and aviation gasoline increased to 9.61%, 0.45% and, respectively, to 0.17%. The CO emissions registered in 2000 were estimated to 53.22 Gg accounting for only 18.58% vs. the 1990 volume.

c. NMVOC emissions

The emissions of the non-methanic volatile organic compounds emissions proceeded from the transport sector in 1990 were estimated to 37.23 Gg. The period 1990-2000 was characterized by a considerable reduction of these emissions from fuel combustion. The emissions of the respective gases in 1995 and 2000 were estimated to 15.12 Gg and, respectively, to 6.90 Gg *(Annex 2.8)*.

These emissions, derived in 1990 from the combustion of: gasoline – accounted for 76.84$, Diesel oil – for 21.90%, LNG – for 0.19%, LPG – for 0.92% and aviation gasoline – for 0.14%. The share of fuel oil and LPG in the NMVOC emissions decreased in 2000 to 20.43% and, respectively, to 0.55%, while that of the gasoline, LNG and aviation gasoline increased to 78.12%, 0.71% and, respectively to 0.19%.

2.3. The development strategy in the transport sector

The concept of the transport sector development until 2010 was worked out by the Ministry of Transport and Road Administration in 1997 [3]. According to that, the development strategy of the transport sector must be focussed on the liberalization of the commodities traffic, the renewal of the existent rolling stock, the further development of the railway, river and maritime transport.

In accordance to medium and long term plans of the Ministry of Transports, the vehicle park must be renewed: the normative term of one transport exploitation unit should not exceed 7 years [3, 4]. At present, this term is of 10 years in the case of the imported vehicles, and over 15 years for the vehicles exploited in the country.

With the purpose to increase the efficiency of the respective branch, it is necessary that the transporters should orientate to the purchasing and utilization in the international traffic of high-tonnage trains (up to 30 tons) [3, 4].

Some desideratum should be established in the urban sector: the opening of some electric transport lines (including the tramway lines in Chisinau), the building of belt highways around the large urban agglomerations [3, 4].

In the railway sector it is stipulated the reestablishment until the year 2005 of the exploitation capacity of the railroads with the purpose to assure the train traffic with a speed of up to 120 km/h. An important step is the electrification of the railroad sector Razdelnaia-Ungheni and the reconstruction of the railway sector Ravaca-Cainari [3, 4].

In the framework of the TACIS designed "The improvement of the transport flows in the trans-European corridors II and IX" there are stipulated measures to modernize the highway Poltava, to reconstruct the railway sector Razdelnaia-Ungheni, and build a new railway sector Slobodca – Voroncгu – Orhei – Chiєinгu – Honceєti – Cantemir – Prut [3, 4].

In the field of the river transport it is forecasted to activate thereof on the river Prut and to construct the Giurgiulesti terminal and a refinery for petrol products on the river Danube [3, 4].

Together with the Government of Romвnia, there will be examined the possibilities to deepen the river Prut in the sector Ungheni-Giurgiuleєti for the development of the commodities traffic [3, 4].

Jointly with the Ukraine, there will be searched solutions to improve the traffic of commodities on the river Nistru in the sector Otaci –Black Sea, as well as the construction of a navigation canal at the Dubгsari hydroelectric power plant [3, 4].

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3. THE RENEWABLE ENERGY SOURCES

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3.1. The current situation concerning the implementing of the RES

I. The wind energy.

The Republic of Moldova has such a geographical placement that only some areas on its territory benefit of favorable winds for the development of the wind energy system. The statistical data shows that until the massive use of the steam engines and of those with internal combustion, the wind installations generating mechanical energy (the wind mills) had an extremely wide spreading on the territory of the current Republic of Moldova. For example, in 1901 there were attested 6,208 wind mills, distributed upon the counties in this way: Brлıoi – 299; Chiєinгu – 980; Thighina – 907; Soroca – 371; Orhei – 626, etc. [1]. In 1923 *The General Direction of the Regional Statistics of Chiєinзu* evaluated, in an official edition, the economical potential of Basarabia's villages [2]. This publication offers us extremely precious data as for the use of the windmills and their territorial disposal. In this way, it was possible to ascertain that some villages had more than 30 windmills. For example, in the central area stand out Costeєti with 23 mills, Lozova – with 30, Buteni – 16, Vгrzгreєti – 28, Truєeni – 23, Scoreni – 17 mills; in the south area: Talmaz – with 15, Cubei – 31, Taraclia – 31, Traianul Nou – 34, Congaz – 30 and Isarlia – 20 mills. Most of the mills, of pyramidal type, were stretched in a chain on the hills, often named "The Mills' Hill". Many of these mills ran also in the period between those two Wolrd Wars.

During the years '50 of the past century, there were more than 350 mechanical wind installations assembled in the country, exclusively destined to the pumping in the water supply systems, and to the fodder preparation at the collective agricultural farmsteads. These were air-generators with many blades and the nominal output of 6,2 horse powers (4,56 kW) at the estimated wind speed 8 m/s. They ran with enough efficiency, being replaced gradually, in the period of 1960 – 1964, by more convenient and cheaper in the exploitation electrical systems. In the long run, the entire rural electrification, that took place in this period, and the very low prices for electricity excluded the wind energy from the competition. At present, only a few experimental wind installations of light output, used for the production of electricity in autonomous conditions, run in the republic. In the last decade, along with the ten times increase of the prices for energy resources, the interest in renewable energy sources increased considerably, and its use may increase in proportions in the forthcoming future.

II. The solar energy

a) Thermal solar energy

The first investigations concerning the solar energy use in the Republic of Moldova were initiated at the end of the 50s of the past century by the co–workers of the Institute of Energy of the Academy of Sciences of the ex-SSRM [2-6]. In that period there were elaborated, assembled and tested the first thermal solar installations: a solar hot house with the heat accumulation in the ground, two solar installations for water heating assembled at the children camps from the villages Vadul-lui-Vodг and Condriюa. Afterwards, as a result of the extremely low prices for the used fuels and of the lack of a consequent policy of renewable energy sources (RES) promotion, the implementing of these installations had been given up.

The works of implementing the sun installations was resumed in the 80s of the XX-th century, along with the serial production of the solar collectors at some factories of the ex-USSR. In the period of 1982–1987, at the specialized institutes "Ruralproiect", "Urbanproiect", "Agropromproiect" solar installations for water heating were designed at the following objectives: a four room's house in the village of Bucuria, county Cahul; 90 places' kinder gardens in the villages of Hвrboveю and Berezchi, district Anenii-Noi; a 240 places' hostel in the village Novoselovka, district Orhei; a 160 places' kinder garden in the village of Mгlгieєti, district Criuleni; a solar tobacco drying stove in the district Briceni, etc.

Most of the solar installations were destined to water heating in the March–October period. The entire area of the sun sunlight collectors was of about 12 thousands m^2, which allowed the substitution of about 1,000 t.c.e. Most of these installations do not run because of the bad quality of the solar collectors, of the corrosion and of the maintenance works' suspending. Starting with 1993, solar installations for water heating are produced in the Republic of Moldova at the enterprise

"Incomaє" JSC. We mention that, so far, there were implemented 140 solar collectors, with an area of 1.4 and 2.2 m^2. The entire area of the assembled installations is of about 300 m^2. The features of such installations are given in the Table 3.1.

Table 3.1. *The features of the solar installations implemented by "Incomas"JSC*

Object's name	The number of the collectors	The collectors' area, m^2
The rest house "Luceafărul", Vadul-lui-Vodă	4	5.8
The children's camp, village of Ivancea	21	30.2
The central market, city of Chişinău	4	5.8
The textile combine, Tiraspol	32	46.0
"Santehmontaj" JSC, Edineț	24	34.6
The stone quarry, Soroca	4	5.8
The department "Autosalubritate", Chişinău	8	18
The piscine of the National Institute of Physical Culture and Sports, Chişinău	12	26.4
The Palace of the Republic, Chişinău	32	46.0
The autorepair plant, Chişinău	2	4.4
The sports center of the Free International University of Moldova, Chişinău	8	18

b) The Photovoltaic solar energy

There were tried only some experimental photovoltaic (PV) installations for water pumping [8] and for communication systems and weather stations. Because the whole population of Moldova has access to the public electrical networks, the PV solar energy may have a relatively limited segment of use: the light irrigation and the rural consumers of electricity with light output, territorially scattered (for example, the anti-hail protection stations, the forest folds, etc.).

III. The biomass energy

The notion of the biomass signifies both the biomass proceeded from the process of the agricultural plants' growing and from the forestry, and that in the shape of organic residues and wastes. The biomass energy proceeded from the forestry is used, in most of the cases, by its direct combustion in the stoves that exist mostly in the houses of the rural environment. In this case, the obtained thermal energy is used for houses heating during the winter and for domestic purposes, regardless of the period of the year. The implementing of the advanced technology of the biomass energy conversion, proceeding from the agricultural and forest wastes, into thermal and/or electricity, is limited by a number of factors, like:

– The high prices of these technologies;
– The limited quantity of such resources;
– The great territorial dispersion.

Because of the high prices of the methane recovery, these kinds of installations are not used currently. Nowadays, only five wastewater-treatment stations (Chiєinгu, Tiraspol, Brlнoi, Thighina and Cupcini) have anaerobic treatment of wastewater and its residual solids by-product-sludge and recovery of the biogas (methane–tankers). The rest of the treatment stations have open fermentations, without biogas collection. As a result, the biogas is emitted in the atmosphere from the drying platforms' area, where the fermented sludge is stored. The conversion of the animal manure energy and of the MSW energy is extremely limited and is carried out only in the framework of some demonstrative pilot projects.

3.2. The potential of the RES implementing

3.2.1. The wind energy

I. The wind energy potential

The argumentation of a designed of implementing the wind energetic objective needs, first of all, the cognition in details of the energetic wind parameters in the area of the future locations and – especially – the probable distribution by wind speed gradations, the daily and seasonal speed variation, the prevalent directions and other parameters.

The wind energy is proportional to the cube of the earth speed in the area of the wind installations' locations. Long-standing systematical observations are necessary to obtain statistical data of a high consideration in this sector. The use, in this purpose, of the long standing systematical observations, performed by the adjacent weather stations, emphasizes two complex problems: first of all, the selection of the way of exploitation of these data on the foreseen location perturbations, caused by the existent obstacles near the weather station and the level changes of the environing territory [17].

The performances of the WAsP program package [18], implemented for the evaluation of the wind energetic potential in the Republic of Moldova, corresponds to these exigencies. As initial data there were used:

– the data base of the State Hydrometeorology Service of the Republic of Moldova [19, 20], that contains the data of the systematical-standard records concerning the average wind speed and direction, performed in 1990–1999;
– the geographical co-ordinates, the description of the obstacles and of the kinds of relief near the station;
– the ore-graphical description of the territory (the digital map)

Of those 18 weather stations, which comprise the State Hydrometeorology Service, 5 were emphasized as representative, the others not being examined because their anemometer was obviously eclipsed by the multitude of obstacles in the immediate proximity.

After the calculations, it was obtained the *Wind Atlas*, containing the average wind speed and the specific wind output at 5 determined altitudes (10, 25, 50, 100 and 200 meters) and for four rigidity categories, referred to the standard-conditions. Besides this table data, the wind rose and the parameters of the Wiebull wind speed distribution repeatability was obtained, both of them being re-calculated in relation with the primary weather data (*Figure 3.1*).

		R-class 0 (0,000 m)	R-class 1 (0,030 m)	R-class 2 (0,100 m)	R-class 3 (0,400 m)
Height 1 (z = 10 m)	ms-1 Wm-2	7,0 322	4,8 125	4,3 83	3,4 40
Height 2 (z = 25 m)	ms-1 Wm-2	7,6 414	5,8 201	5,2 148	4,4 88
Height 3 (z = 50 m)	ms-1 Wm-2	8,2 505	6,7 286	6,2 221	5,3 145
Height 4 (z = 100 m)	ms-1 Wm-2	8,9 658	8,0 460	7,3 352	6,4 235
Height 5 (z = 200 m)	ms-1 Wm-2	9,8 922	9,9 911	9,0 680	7,9 439

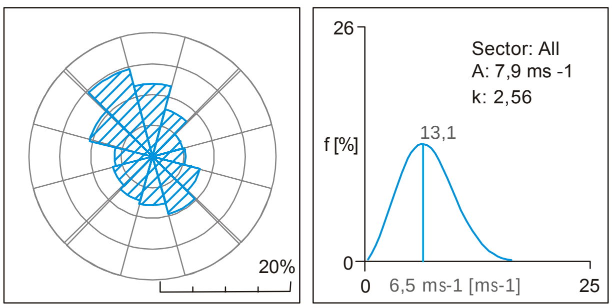

Figure 3.1. *The Wind Atlas*

The Wind Atlas describes the wind and the energetic conditions that concern a certain point – at the station where the measurement had been performed. On the basis of these data, by extrapolation, the same features for any wished location from the neighborhood will be calculated, in the radius of 50 km. The wind energetic potential is usually expressed as a "*Map of the Wind Resources*". This map shows the climatic and energetic final values of the wind for any land area, the "Atlas" data being extrapolated and fitted to the air-graphic examination of the ground.

In the Annex 3.1., the map of the wind resources from the weather station Ciadвr-Lunga neighborhood – a representative territory from the south of the Republic (with the maximal altitude of 200 m) – is offered. In the adjacent table there are indicated the average yearly speeds and the specifically available outputs (W/m^2) calculated for standard – altitudes. Analogical calculation had been made for about 100 similar ground portions that include the whole territory of the republic. *The wind Energetic Potential's Map* (70 m from the ground) for the territory of the Republic of Moldova is offered in the Annex 3.2. For some sectors, the precision degree of the calculations may be smaller, because of the extra polar distance, that exceeds 50 km (from the referential weather station), but these calculations may serve as a reference point for the emphasis and the appreciation of the future locations, and the wind potential could be precisely determined with the future measurements in any wished point.

At the actual level of development, the "commercial" wind energy conversion's technologies, the locations that assure an average yearly speed at the wind turbine axe's altitude of 7 m/s and more with the specific wind energy higher than 350 W/m^2 are considered favorable. On these criteria it may be concluded that the Republic of Moldova has quite extended zones with a favorable for energetic exploitation wind potential, of which the most important are:

– The Tigheci heights;
– The Nistru region's heights;
– The Ciuluc hills;
– The central tableland of Moldova;
– A great part of the hill's territory of the Cahul and Taraclia counties.

After some minute evaluations, perspective locations may be emphasized also in the considered favorable zones. That is some predominant hills in the proximity of accumulation lakes (Dubrsari, Ghidighici, Ialoveni, and others). It is to mention that, besides the meteorological features, the following factors are decisive in the location's selection:

- The proximal existence of the transportation roads and the electrical networks;
- The economical factors, for example, the price of the land;
- The ecological factors: birds' migration ways, natural reservations, etc.;
- Security restrictions imposed by air circulation.

The favorable conditions for transportation and the relatively cheap access to the public electrical network, in the Republic of Moldova are ensued thanks to the developed networks of roads and electrical lines. The distances from the eventual locations to the covered road are at the most of 5 to 6 km. An eventual electrical line to couple the power plant with the networks of 10 kV also will not exceed the 5 – 10 km length. These factors will allow the considerable diminution of the necessary for the setting up of the wind power plant's expenses.

Meteorologically, the most appropriate lands for locations are the combs and the slopes of the hills. These lands, usually arid, with a reduced fruit-fulness, are less favorable for the agriculture, serving only for grazing. The price of these lands will be minimal, and their restoration for utilization will not need additional expenses.

II. The Wind Technologies and Installations

In accordance to the way of using the obtained energy as a result of the wind energy conversion, the wind installations may be mechanical and air–generating. In the first case, the energy is used directly in the effectuation of a mechanical work, while the air – generating installations transform the mechanical energy in electricity.

The wind generating sets for pumping are mechanical installations that may be used especially in the farms. These installations are usually endowed with plunger pumps or Vergnet work pumps, being driven from the air – engine shaft by a rod. The many blade turbines that, starting with a low speed, develop a large couple engine, sufficient for the pump's work, ensure an efficient use of the wind energy at different wind speeds. The air – engine rotation is increasing along with the increasing of the wind speed, which assures a proportional increase of the pump debit at an actually constant pressure. The efficient use of the pumping mechanical installations requires the existence in the same place of a water source and of the favorable wind conditions.

The electricity production is the most effective way of using the wind energy, because of the high output of the conversion process and of the insignificant damage in the transport line as far as the place of using the energy. There are known three ways of using the air–generators in an electricity production system [21-23], where the regulation and stocking energy problems are solved differently:

1. *Autonomous systems,* where the air–generating installation (one or more) entirely covers the electricity demand.
2. *Autonomous combined systems,* where the wind power plant delivers energy to the common network along with other electricity generating sources of a comparable power with the generator.
3. *Wind energy power plants (WEP),* usually with more air–generating installations (wind farms), those deliver energy to the public network, at an incomparably higher output than the air– generator's settled output.

Because of the high prices for the energy's regulation and accumulation, the autonomous systems need substantial capital investments, the price of the obtained electricity being also high. The use of these systems may be motivated only in special cases, like those of isolated consumers. Their number in the Republic of Moldova is very limited, as a result of the density of the localities and of the electrical distribution networks. In the Republic of Moldova's conditions, the optional way of exploitation of the wind energetic potential is the construction of wind energy power plants with connected to the public network air–generators. More air–generators, usually in groups of 30 to 50 units, form an WEP, being connected to the public network through one or more transformers for increasing the voltage.

Considering the following circumstances – the specific nature of the electrical load distribution on the republic's territory, the limited area of locations with good meteorological conditions and of the grounds that may be withdrawn of the agricultural circuit, and also the small financial possibilities of the population – it is considered that the WEPs with an installed capacity of 10–15 MW will have a larger spreading in the Republic of Moldova. After a minute examination [24] of about 50 scenarios of equipping some eventual WEPs with made by European firms air–generators, it was concluded that, in the Republic of Moldova's conditions, the most efficient are the air – generators with a installed capacity of 0,6 – 1,5 MW, the specific nominal energy of 350 – 600 W/m^2 and the tower's height of 70 – 95 m. Such air–generators are produced by the firms DeWind, Bonus, NEG Micon, Nordex, Enercon, Vergnet work, Wincon, i.e. These aggregates also foresee the rotation regulation depending on the wind speed and, respectively, on the use of the available output in the low wind speed areas.

The results of the calculation concerning the economical efficiency of an eventual WEP with the power of 3 MW, located in the area of the meteorological station Ciadвr-Lunga (*Annex 3.1*) are given in the *Table 3.2*. In this way, it may be observed that the price for the energy produced at this power plant is of about 5 cents/kWh, a favorable economical price even at the current prices of delivering electricity to the consumers. Where placement conditions are most favorable (Annex 3.2), the price of the produced by the power stations energy will be of 4 – 4,5 cents/kWh.

The factors that may contribute to increase the economical advantages of the WEPs are:

- perspective locations situated close to the electricity networks;
- favorable daily and season graphic of the wind speed, having the highest amounts in the top hours and in the months when the electricity consumption is maximal.

3.2.2. The Solar Energy

I. The available potential of solar energy

In the Republic of Moldova, the theoretical duration of sun shine is of about 4,445–4,452 hours a year. The real duration makes up 47–52% or 2,100–2,300 hours (*Figure 3.2).* A considerable part of the sun shine hours are in the months of April–September and makes up 1,500–1,650 hours. The global radiation in conditions of middle nebulosity makes up 1,280 kWh/m^2 per year in the North area and 1,370 kWh/m^2 per year in the South (*Figure 3.3*).

Table 3.2. *Technical-economical indexes for a 3 MW wind energy power station*

Parameter, indicator, criteria / Variant	A	B	C
Installed capacity of the WEP, MW	*3*	*3*	*3*
Airgenerator (AG) type	*Nordex N-29*	*DeWind D4*	*DeWind D6*
AG nominal output, kV	*250*	*600*	*1,000*
Rotor diameter, D_r	*30*	*48*	*62*
Tower's height, H_o	*50*	*70*	*91.5*
Number of airgenerators	*12*	*5*	*3*
Factor of using the nominal output, k_u	*0.304*	*0.372*	*0.42*
Yearly energy volume produced by the power station, thousands kWh/year	*7,989*	*9,776*	*11,037*
Actualized energy volume W_a produced in the entire period of the power station's life, thousand's of kWh	*60,742*	*74,356*	*83,947*
Actualized period of life of the generators, T, years	*7.606*	*7.606*	*7.606*
Investment in the WEP, thousands Euro	*3,753*	*3,523*	*4,117*
Specific investment in the WEP, Euro/kW	*1,233*	*1,276*	*1,370*
Yearly exploitation expenses, in relative units, α_E	*0.01*	*0.01*	*0.01*
Average yearly exploitation expenses $C_{ex}=\alpha_E \cdot I$, thousands Euro/year	*37.5*	*35.2*	*41.7*
Yearly price of the initial investment and of the loan, R_i thousands Euro/year	*492*	*461*	*539*
Average yearly expenses CA, thousands Euro/year	*529*	*496.2*	*581*
Total actualized expenses on the installations period of life, CTA, thousands Euro	*4,024*	*3,791*	*4,429*
Price of the produced energy, C_W, Euro/kWh	*0.067*	*0.0508*	*0.052*

Figure 3.2. *The sun shine period, h/year*

Source: Lasse G. F. The climate of the SSRM. Ghidrometeoizdat, Leningrad, 1978 (original in Russian)

Figure 3.3. *The yearly amounts of the global sun radiation. KWh/ (m²/year)*

Source: Lasse G. F. The climate of the SSRM. Ghidrometeoizdat, Leningrad, 1978 (original in Russian)

For the priority technologies (*water heating installations; fruit, vegetables and medicinal plants drying installations and photovoltaic - PV installations)* the available potential of energy has been determined, taking into consideration the exploitation period of the installations, the sun radiation particularities and the inclination angle of the collector or of the PV modulus. For this purpose, it was used the method described by J. Duffie and W. Beckman [15]. The data concerning the solar radiation on a horizontal area in conditions of middle nebulosity and clear sky had been taken from the State Hydrometeorology Service publications [16–18].

For the water heating, agricultural-food drying and pumping installations were determined the average monthly amounts of used solar energy in the respective periods of running. The optimal inclination angle of the collectors, or of the PV modulus, also had been calculated. As optimizing criteria, the maximal amounts of the solar radiation in the top months of the exploitation period, when the solar radiation on a horizontal area is lowering, had been chosen. For the PV pumping installations, the fact hat they run effectively only in the sun shinning hours had been taken into consideration.

a) Water heating installations

The efficient period of exploitation of the water heating installations makes up about 7 months – March–October period. The optimal inclination angle had been calculated using as an optimizing criterion the sun radiation in the month March and October (*Figure 3.4*). For the optimal inclination angle β= 40, the global sun radiation increases in March with 21%, in October – respectively with 50%, and in July it lowers with 10% in comparison with the horizontal plan of the collector.

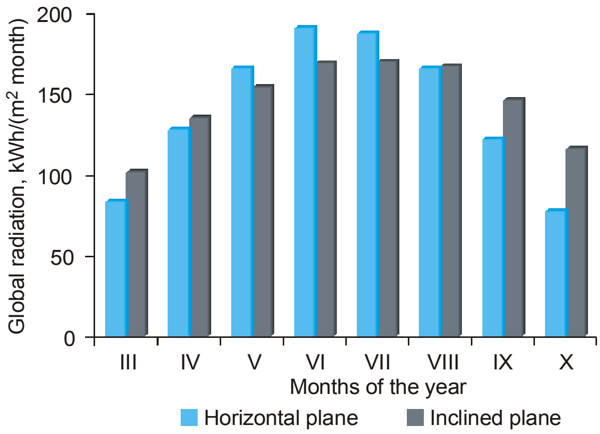

Figure 3.4. *The utilizable radiation in the period of March–October for a water heating installation. Inclination angle – 40⁰*

b) Fruit, vegetables and medicinal plants drying installations

The exploitation period of these installations coincides with the maximal solar radiation period, extending usually on the period of May–October. The same installation may be used for the medicinal plants, fruits, vegetables and proceeded from the agricultural products refuse drying. For increasing the utilizable global radiation in September–October the optimal inclination angle of the solar collector had been considered, fixing that it has the amount of 35^0. In comparison with the horizontal plane of the installation, for this angle, in September the global radiation will be 20% higher, and in October – 46% (*Figure 3.5*).

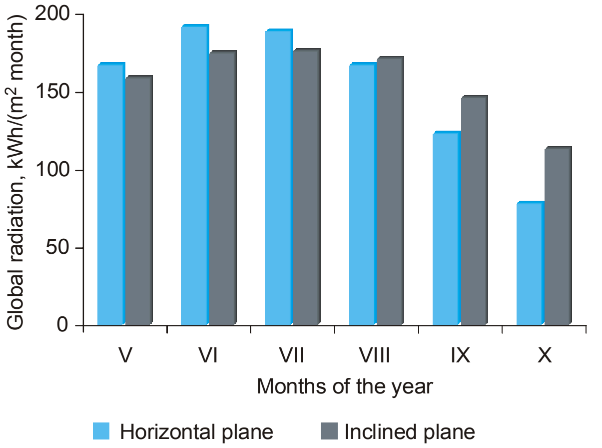

Figure 3.5. *The utilizable radiation in the period March – October for a drying solar installation. Inclination angle – 35^0*

c) Photovoltaic pumping installations

Unlike the thermal sun installations, the pumping installations without electricity accumulators ran only in conditions of clear sky, in other words, as long as direct radiation exists. The reasonable amounts of the sun radiation are lower than in the previous cases, because there had been considered only the real sun shinning hours (*Figure 3.6)*

II. Solar energy conversion technologies and installations

There are known four ways of solar energy conversion: thermal, electrical, chemical, and mechanical. The first two are the most used worldwide, have an advanced level of technical and technological perfection and a developed sales market.

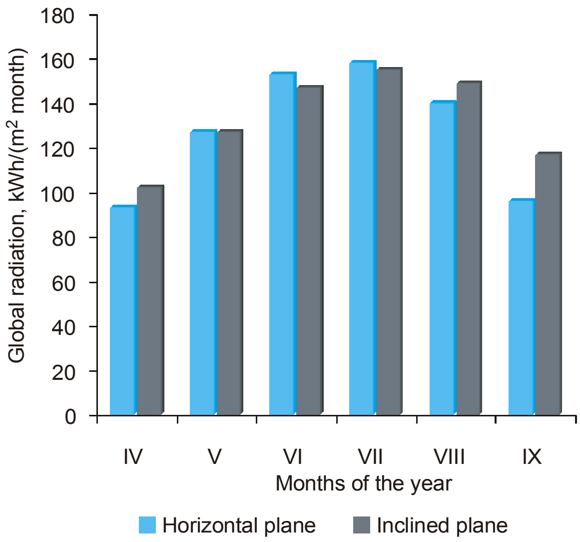

Figure 3.6. *The utilizable radiation in the period April – October for a PV pumping installation. Inclination angle – 25^0*

a) The thermal conversion of the solar energy

The thermal conversion is the oldest and the most spread way of using the solar energy. Any black surface, exposed to the sun rays, named collector or absorbent surface, transforms the solar energy into heat.

Solar collector at low and middle temperatures. In this category of installations the systems of conversion of the diffuse and direct radiation in thermal energy at temperatures of to 150^0 C are included. Two types of collector are used: plane and with empty tubes.

The plane collector is used for water or air heating up to 60^0 C, it has a simple construction, with a metallic or plastic absorbent plane through which the calo-bearer (water, air or anti-gel) runs. To increase the efficiency of the collector to 40-60%, the absorbent surface is thermally isolated from all sides, except for the surface exposed to radiation, and covered with a transparent plate. These systems can supply hot water or air for sanitary needs, the piscine, locative and commercial spaces heating, ventilation and acclimatizing, agricultural products drying.

The collector with empty tubes is a more recent construction, where the thermal isolation is realized through the forming of advanced level emptiness into the tube where the absorbent plate is situated. The output of the respective construction is of 50 – 70%, the calo-carrier liquid heating being assured to 150 ^{0}C. The price of such a collector is about three times higher than the price of the plane one.

Solar collectors at high temperatures. High temperatures of hundreds and even thousands of grades can be obtained through the sun radiation's concentration. The collectors are gifted with devices of following the sun either on a single co-ordinate or on two co-ordinates. This technology is used in different industrial processes in the production of the electricity, of the hydrogen, of the water steams, etc. Of the variety of collectors we will mention the following three, more often used: cylinder-parabolic, parabolic and heliostat concentrators.

b) The electrical conversion of the solar energy

The electrical conversion of the solar energy is based on three physical effects: thermal-ionic, thermal-electrical, and photovoltaic (PV). The highest level of development in technical, technological and commercial respects had been reached by the PV conversion. The PV cell, on the basis of a semi-lineing material, is the principal component of a solar generator. The PV cells of crystal and semi-crystal Silicon (80%) and of amorphous Silicon (10%) have the highest commercial spread.

Because of economical, social, energetic and environment infrastructure considerations, the following technologies and installations had been observed:

– Water heating installations for domestic use (with plane collector);

– Agricultural products drying installations, using the air plane collector;

– Water pumping installations, using the PV conversion;

– Installations for PV conversion for electricity supply of the spread consumers and those with little power.

c) Solar collector installations for water heating

In accordance to their way of running, the solar installations for water heating may be with forced and natural circulation (thermal siphon) of the calo-bearer, with one or two circuits. The simplest and, respectively, the cheapest, are the installations with natural circulation and with a single circuit. But, because they are not resistant to frost, these installations must have a seasonal use, usually in the period April–October. The installation with two circuits and forced circulation has a pump in the first circuit that assures the forced circulation of the calo-bearer anti-gel liquid, by transporting the heat from the solar collector to the accumulation reservoir, where, with the help of the heat exchanger, the thermal energy is transmitted to the water of the second circuit and further to the hot water consumer. These kinds of installations may run also in the cold period of the year. Considering the experience of the EU states and that of some CIS states with similar climatic conditions to those of the Republic of Moldova, we conclude that in the case of our Republic the following solar installations are appropriate:

– *Individual installations with a single circuit*, natural circulation, area of the collector of 2-4 m^2, accumulation reservoir of 100-200 l., seasonal use and that assures hot water to a 2-4 person's family. The segment of the implementing market is the rural area, especially the non-gasified villages;

– *Collective installations with a single circuit*, natural circulation, the area of the collection of 10-30 m^2, an accumulation reservoir of 1-2 t, seasonal use and that assures hot water to the shower rooms, summer camps, sanatoriums and other recreation centers;

Table 3.3. *The technical features and the price of the individual solar installations for the hot water production*

Type of the installation	Country	Area of the collector, m^2	Way of running	Price of the installation, US$	Specific price, US$/$m^2$
KSV	France	*4*	Forced, two circuits	*1,940*	*485*
KSH	France	*4*	Natural, one or two circuits	*1,804*	*451*
ECS-4	France	*4*	Forced, two circuits	*2,268*	*567*
Kit A4	Austria	*4*	Forced, two circuits	*2,280*	*570*
Dynasol 300	Belgium	*4*	Forced, two circuits	*2,604**	*651*
BW470 plus	Germany	*6*	Forced, two circuits	*2,982*	*497*
Solami	Israel	*2.8*	Natural, one circuit	*1,737*	*620*
INCOMAŞ	Moldova	*4*	Natural, one circuit	*750*	*188*

– *Collective installations with two circuits*, forced circulation, the area of the collector of 20-100 m^2, an accumulation reservoir of 2-10 t endowed with supplementary heaters that consume little traditional fuel. They run during the whole year. The segment of the implementation market is the common spas, schools, kinder gardens, refectories, piscines.

We offer below the technical features and the price of the individual and collective installations industrially produced in different countries (*Tables 3.3 and 3.4)*.

The specific price of the installation is referred to a square meter of installed collector. For the import installations, the average specific price is of US $ 530/m^2. In accordance with the calculations, a 3-4 persons family may be assured with hot water by a solar collector with an area of about 4 m^2. For some selected individual and collective installations (*Tables 3.3 and 3*.4) the relevant economical indicators have been calculated (*Table 3.5*).

It was accepted that the observance is of 20 years, the level of actualization – of 10%, the yearly exploitation expenses – of 1% of the installation's price. The rate of exchange of the national currency was considered of 13 MDL per 1 USD. The volume of thermal energy produced in the installation corresponds to the meteorological conditions of the Republic of Moldova and to the period of running from the 15th of March till the 15th of October. So, the offered economical indicators (*Table 5.3.*) make us affirm the following:

– The price of the thermal energy produced by a solar installation is of 500 – 1,500 MDL/Gcal, that is much more than the actual price of 233 MDL that the consumer pays for a produced at the cogenerating CHP Gcal, located in the large cities and running on natural gas, but it is comparable to the price of 1,000 MDL for a produced by an electrical boiler with a 100-150 l volume Gcal – nowadays a very spread installation in the urban area.

– Economically, the individual and collective solar installations are more favorable for the hot water consumers of the rural area, especially for those who do not have the access to the natural gas network. For an individual installation, destined to a 4 members family a yearly benefit of 50, 150 and 225 USD per capita may be obtained, in comparison with the situation when for this purpose is used coals, electricity and LPGs [Renewable energy. Feasibility Study. Chişinău, 2002].

d) sun installations for the agricultural products and medicinal plants drying

The agricultural products drying, one of the oldest conserving technologies, is also the most widespread in the world. More than 2,600 solar drying stoves, of which 800 in the EU countries, with a collectors area of more than 200,000 m^2, were running in the middle of the 90s of the XXth century in the West and Central Europe. The main sectors of using these installations were the fodder, cereal products, fruits and vegetables, aromatic and medicinal plants drying, etc. In accordance with the way of action of the solar radiation on the products, there are known three types of solar installations: direct, indirect and combined.

Table 3.4. *Technical features and the price of the collective solar installations for the hot water production*

Locality, country	Area of the collector, m^2	Volume of the reservoir, m^3	Way of running	Price of the installation, US$	Specific price, US$/$m^2$
Center of recreation, Tisvodeledje, Denmark	*219*	*5*	Forced, two circuits	*139,700*	*637*
Municipality Goerlev, Denmark	*77*	*2*	Forced, one circuit	*35,500*	*461*
Piscine, Glamsbjerg, Denmark	*560*	*16x50x1.6*	Forced, one circuit	*27,600*	*50*
Center of recreation, Anapa, Russia	*38*	*4*	Forced, one circuit	*5,714*	*150*
Kinder garden, Temriuk, Russia	*22*	*2*	Forced, one circuit	*2,750*	*125*
Shower rooms, Autosolubritate, Chişinău	*18*	*2.5*	Natural, one circuit	*2,330*	*129*
Refectory, shower rooms, Vatra, "Varnest" Moldova	*8*	*0.8*	Natural, one circuit	*1,000*	*125*
Shower rooms, FIUM, Chişinău	*18*	*2*	Forced, two circuits	*4,953**	*276*

Table 3.5. *Economical indicators of the individual and collective solar installations for water heating*

Type of the installation, country / Economic indicators		Individual		Collective			
		KSH France	Incomaş Moldova	Goerlev Denmark	Glamsbjerg Denmark	Temriuk Russia	Varnest Moldova
Volume of the produced energy, MWh/year		*2.25*	*1.8*	*43.1*	*252*	*9.9*	*3.6*
Total actualized expenses, US$/year		*230*	*95.6*	*4526.6*	*3519*	*350.6*	*118.7*
Price of the thermal energy	USD / kWh	*0.102*	*0.053*	*0.105*	*0.014*	*0.035*	*0.033*
	MDL / Gcal	*1545*	*802*	*1586*	*211*	*535*	*498*

In the direct action installations the sun rays action directly on the product. Constructively, they present a carcass with grates (shelves), covered with a transparent material, usually with a film, that assures the obtaining of the hot house effect and the product protection from the dust, rain, insects. The installations with direct action are simple and cheap. But they also have a number of disadvantages like: low output (0.15-0.20), specific little productivity (kg/m^2), impossibility of controlling and ruling the process (the temperature and the drying agent speed), the quality depreciation of some products after the direct action of the sun rays, etc.

The installations with indirect action are those where takes place the convection drying with the help of the previously heated air in the solar collector. Their main advantage consists in the possibility of avoiding the degradation of the processed products' quality.

The installations with combined action combine the technological features of the installations with direct and indirect action. These installations are constructions with double roof, with the function of a solar collector where the air heating takes place. The destined to the drying product is placed in the drying room where the hot air is directed through a line by a ventilator. These installations have a superior output and productivity in comparison with those with indirect action.

Most of these installations with this destination are not industrially made. They are assembled at the destination place, in accordance with individual design. The specific prices (USD/m^2) differ from case to case and vary from USD/m^2 5 to 60, depending on the type of the installation and of the used materials. Further on the results of the calculations concerning two types of solar installations are described: the first – for fruit and vegetable drying, combined type (wood carcass, collection with transparent film); the second – for medicinal plant drying, with indirect action, forced ventilation, double roof formed collector (*Table 3.6*). In both cases, it was admitted an actualization rate of 10%, yearly exploitation expenses – 5% of the initial price. The transparent film for the first drying stove is changed every year. It was concluded that, for the meteorological conditions of our country, the use of the drying stove is economically advantageous. The price of a Gcal of thermal energy, resulted from the solar energy conversion through these technologies is several times lower than the price of a Gcal obtained at an installation that uses in this purposes the Diesel oil. In case of using the technologies where, as a source of energy, is used the Diesel oil, only its quotation part in the price of a Gcal makes up 680 MDL.

Table 3.6. *Technical and economical indicators of the solar drying installations*

Installation type / Indices	Combined	Indirect
Collector area, m^2	*24*	*42*
Output, %	*50*	*35*
Produced thermal energy, MWh/year	*10.2*	*13.8*
Study period, years	*10*	*25*
Period of running, days/year	*150*	*180*
Price of the installation, US $	*410*	*1,750*
Total actualized expenses, US $/year	*99.7*	*280*
Price of the thermal energy, US$/year, (MDL/Gcal)	*0.01(148)*	*0.02(296)*

e) Solar installations for light irrigation

The notion of solar pump emerged in the middle of the 70s of the last century. Regardless of the pump running principle, the notion concerns the pumps that more correspond to the particularities of the supply source – to the photovoltaic (PV) modulus and to the variable character of the solar radiation. A solar pump is different from a traditional one by the following:

- It has a much higher output at little powers that do not exceed some tens or hundreds of Watt.
- It assures the water pumping at the total manometer altitude (TMA), specified at a quite great variation (approximately two times) of the sun radiation intensity.

– It may be brought into function from a PV modulus that does not exceed the absorption capacity of the pump in the nominal conditions of 1.2-1.3 times (an important feature of this pump is the fact that it needs little power on the moment of operation).

In accordance with the way of exploitation, the solar pumps are classified into two large categories: submersible and surface ones. The submersible pumps are exploited below the water level and pump from any water source – wells, including artesian wells, rivers, lakes, accumulation basins, reservoirs, etc. Because they have the capacity of 5-7 m, the surface pumps may be used only in the case of surface water sources: rivers, lakes, accumulation basins. The submersible sun pumps are 2-3 times more expensive than the surface ones. Nowadays, of the more than 70 known construction designs of pumps only few are used as solar pumps: volumetric (with piston, helicoids, with diaphragm, with piston and diaphragm) and centrifugal. In the following table the technical features and the prices of the volumetric and centrifugal solar pumps are given (*Table 3.7*)

Given that the nowadays commercialized solar pumps have an actually low capacity, it is recommended to use a reservoir where the water should be accumulated. Such technologies allow the use of the low power PV modulus. In consequence, the price of the entire installation could be reduced. Indifferently of the way of exploitation, the solar pumps may be endowed with different types of engines: of continuous power with permanent magnet works with or without brushes (in the second case, the system has an electronic commutation block that substitutes the collector ensemble – brush and that increases the prices considerably), of alternative power, usually asynchronous.

The water pumping, using the solar energy, is considered one of the most widespread technologies. The solar technology of water pumping reached a high level of technical and commercial development. In the past ten years there were installed more than 50,000 solar systems of water pumping in the now being developed countries to supply with drinking water the villages non-connected to the public electrical networks and for the light irrigation.

In accordance with a study performed by the World Bank (World Bank Technical Paper No. 168), the solar pumping of the water for supplying the consumers that do not have access to the network is competitive with the electrogenic group (engine with internal combustion – generator) if the demand does not exceed 800 m^4/day – the result of the multiplication the water volume to TMA. For example, the pumped water volume is of 40 m^3/day, TMA – 20 m or, respectively, 20 m^3/day, TMA – 40m. The solar pumping in the light irrigation purpose is competitive with the electrogenic group on a reduced segment – the irrigated area will not exceed 0.5-1.5 ha if we use the traditional technologies or 2-3 ha if we use the dripping irrigation. In this case, the produced volume – AMT will not exceed 450 m^4/day.

A solar installation for water pumping has three different components:

– The PV modulus that assures the conversion of the solar radiation into continuous power electricity;

Table 3.7. *The technical features and the prices of the solar pumps*

Type of the pump		Producer	Construction particularities	Features			Price, US $
				Debit, m^3 /h	TMA, m	Operation voltage, V	
SWT-4		Solar Water Technologies USA	Submersible. Volumetric with 4 pistons and diaphragm. Continuous power engine with brushes	*0.45-0.35*	*30-60*	*12-30*	*675*
Sun Rise	5226 5230	Fluxinos Italy	Submersible. Volumetric with 2 pistons and diaphragm. Continuous power engine with brushes	*0.85-0.6* *1.5-1.1*	*8-75* *8-30*	*24-48*	*1,850* *2,150*
SDS-128 SDS-228		Solarjack USA	Submersible. Volumetric with diaphragm. Continuous power engine with brushes	*0.5-0.35* *0.3-0.2*	*0-35* *0-70*	*12-30*	*571* *571*
SCS		Solarjack USA	Submersible. Centrifugal. Continuous power engine without brushes.	*11-0.5*	*0-200*	*30-180*	*1,050-2,000**
SP3A-9		Grundfos Germany	Submersible. Centrifugal. Alternative power engine	*4.1- 2.2*	*10-30*	*3x220*	*1,750*
Sun Centric	7230 7340	Northern Arizona Wind & Sun. Inc. USA	Surface. Centrifugal. Continuous power engine with brushes	*12-2.3*	*11-25* *17-30*	*18-36* *18-36*	*765* *820*

– The converter of the continuous power into used continuous power in the case of the continuous power engines or of the converter of continuous power into alternative power – in the case of the alternative power engines;
– The electrical submersible or surface pump – assures the water pumping.

In the Table 3.8 there are given the calculation results of the price of a m^3 of pumped water, using different solar installations in the conditions of the Republic of Moldova. For comparison, there are also given the prices in case of the alternative scenarios: the extension of the electrical network on an area of 1 km or the use of an electrogenic group.

For all the scenarios were admitted the following indexes: TMA=30 m; the price of a PV power watt is of US $4; the price of the auxiliary elements (cabling, modulus support) – 4% of the total price of the installation; the number of the hours of running in the period of irrigation – 1,200 h/year; the sun pump and the converter are renovated in 10 years; the period of observing is of 20 years; the actualization level – 10%; the inflation rate – 2%; exploitation expenses – 1% of the initial investments.

It is deduced that, in our country's conditions, the price of a pumped cubic meter of water, using the solar energy, is much lower than in case of the electrical network extension or of using an electrogenic group. The installations with surface pumps need the lowest costs.

3.2.3. The biomass energy

I. The available potential

The main generators of used in energetic purposes biomass in the Republic of Moldova are the forestry, the agriculture, the livestock sector, the food industry and the residential sector.

For example, the State Forestry Agency "Moldsilva" yearly delivers to the national economy 250-350 thousands m^3 of fire wood (Table 3.9), so as 60-70% of the rural population buys and use as fuel for heating the houses.

Table 3.9. *The quantity of primary energy resources (fire wood) in the period 1990-2000*

Units	1990	1995	1996	1997	1998	1999	2000
Thousands m^3	*253*	*283*	*352*	*355*	*344*	*298*	*287*
Thousands t.c.e.	*68*	*76*	*94*	*95*	*92*	*80*	*77*

In the context of the energetic balance of the country, the forests are an especially important renewable bioenergetic source, being characterized by:

– Relatively low prices for re-generation;
– The presence of considerable areas able for forestations (degraded lands, located under high voltage electrical networks areas, the communication ways' verge, etc.).

Some aspects concerning the population insurance with fuel are considered in the *Strategy for Sustainable Development of the National Forest Sector, approved through the Government Resolution No.350-XV of the12th of July 2001,* that stipulates the energy forest culture creation. The main species that may be used in this purpose are the acacia, the indigene and Euro-American poplars, the willow and the red oak. All these species are characterized by fast and substantial growing in the wood mass, relatively short production cycles (20-40 years), so as, at the end of a cycle, the respective species may reach the volumes of 150 m^3 (acacia), to 400 m^3 (poplar) per ha.

Table 3.8. *The technical and economical indexes of the solar pumping installation for light irrigation*

Type of the installation. Construction particularities	Water volume, m^3/year	Irrigated area, ha	Power of the modulus, PV, W_c^*	Price of the installation, US $	Price of 1 m^3 of water, US $		
					Solar installation	Network extension, 1 km	Electrogenic group
OA150 System. USA. Volumetric submersible pump. Continuous power engine with brushes.	*540*	*0.25-0.5*	*150*	*2,075*	*0.57*	*2.61*	*0.85*
Sunrise 5230. USA. Volumetric submersible pump. Continuous power engine with brushes	*1,360*	*0.5-0.75*	*300*	*3,737*	*0.45*	*1.74*	*0.68*
Grundfos SP3A-9. Germany. Centrifugal submersible pump. Alternative power engine	*2,640*	*1-1.5*	*800*	*5,470*	*0.30*	*0.87*	*0.51*
Suncentric 7340. USA. Centrifugal surface pump. Continuous power engine with brushes	*2,736*	*1-1.5*	*1,000*	*4,968*	*0.26*	*0.87*	*0.51*

In the meantime, in the process of implementing the care cuttings of those plantations, it may be collected on an average per year other 1 m^3 wood mass per ha or 20-40 m^3 during the cycle. Of the respective volume the working wood will make up cca 15-40%. For increasing the economical efficiency, the resulted from twigs and brush wood mass may be subjected to the mincing.

Another important source of renewable energy in the Republic of Moldova is made up by the agricultural provenience biomass, obtained from the pruning of the orchards and vineyards, and also the one obtained as vegetable residues in the agricultural sector: vegetal residues from the corn (straw and cobs), sun flower, tobacco, wheat and barley cultivation (straw). In accordance with the estimations of the specialists from the Ministry of Agriculture and Processing Industry, from the State Agricultural University, the Technical University of Moldova, the Institute of Energy of the ASM and the Department of Statistical and Sociology, the energy potential of the biomass is impressive (*Table 3.10*), but it is to be capitalized more efficiently.

Other great biomass generators are the livestock sector, the food industry and the communal husbandry of the residential sector. Of the organic refuses proceeded from these sources (*the animal dejection from the livestock farms; organic refuses from the food industry and the leather processing industry; the municipal solid wastes; the sludge accumulated by the wastewater handling process at the municipal and industrial treatment plants; the residual waters with an increased containing of biodegradable organic materials, etc.)* appreciable quantities of biogas, recoverable through the anaerobic bioconversion processes, may be obtained [20-23].

Animal manure. The biomass generating potential depends first of all of the economical factors. So, for example, the generating potential of the animal manure in the livestock sector is determined by the animals and birds population (*Table 3.11*), by the animals and birds feed intake, feed digestibility and, respectively, by their productivity (average weight gain per day, milk production per day, eggs production per days etc.).

Table 3.11. *The animals and birds effective at the end of 2000, thousand heads*

Groups of animals and birds	Total	Collective farms	Individual farms
Bovines	*394*	*83*	*311*
including dairy cattle	*269*	*38*	*231*
Swine	*447*	*165*	*282*
Sheep and goats	*938*	*75*	*863*
including sheep	*830*	*75*	*755*
Horses	*71*	*16*	*55*
Poultry	*12701*	*1651*	*11050*

Because in the Republic of Moldova the quantity of manure (dry substance – d.s.) from the dairy cattle is of 10.6, from the swine – of 5.9 and from the laying poultry – of 12.9 kg/1,000 kg of an alive animal per day, and the quantity of possible obtained biogas from 1 kg of d.s. from the bovines – 260 – 280, swine – 480 and poultry 520 l/kg d.s. [24], the estimated calculation of the biogas emitted from the anaerobic fermentation of the animal manure indicate the volumes offered below (*Table 3.12*).

Taking into consideration the way of growing and taking care of the bovines and horses, it was considered in season to exclude them of the calculus. So, it is supposed that in the anaerobic installations only about 67.09 mil. m^3 of biogas per year could be recovered.

Table 3.10. *The estimated potential of the primary energy resources of the biomass of agricultural provenience, the period 1980-1999, thousands of t.c.e.*

The type of the biomass	1980	1985	1990	1995	1996	1997	1998	1999
Orchards	*151.5*	*166.2*	*199.8*	*191.6*	*195.7*	*199.7*	*195.7*	*187.7*
Vineyards	*107.2*	*91.2*	*91.7*	*92.2*	*90.6*	*88.5*	*84.2*	*78.8*
Wheat	*231.9*	*220.1*	*266.4*	*265.8*	*158.9*	*271.9*	*224.6*	*188.2*
Barley	*44.1*	*73.6*	*98.7*	*67.9*	*27.8*	*55.1*	*50.9*	*43.1*
Corn for grains	*185.6*	*149.3*	*118.7*	*121.7*	*132.5*	*230.2*	*166.1*	*152.9*
Sun-flower	*59.7*	*47.2*	*47.3*	*38.2*	*51.9*	*32.9*	*37.4*	*53.6*
Tobacco	*14.7*	*16.2*	*10.7*	*4.3*	*3.1*	*3.8*	*3.9*	*3.6*
Total	***794.7***	***763.8***	***833.2***	***781.8***	***660.5***	***882.1***	***762.8***	***707.9***
National balance of the primary energy resources	*14,308*	*17,756*	*18,225*	*5,617*	*5,334*	*5,180*	*4,521*	*2,911*
The estimated potential of the energy resources of agricultural biomass as percentage of the national balance	*5.6*	*4.3*	*4.6*	*13.9*	*12.4*	*17.0*	*16.9*	*24.3*

Table 3.12. *The estimated potential of generating the biogas from the animal manure*

Poultry and animals	Specific quantity of biogas, m^3/100 kg of alive animal	General quantity of biogas			
		In the individual farms		In the collective farms	
		thousands m^3/day	mil. m^3/year	thousands m^3/day	mil. m^3/year
Bovines	*3.28*	*306.00*	*111.69*	*81.67*	*29.81*
Swine	*2.62*	*73.88*	*26.97*	*43.23*	*15.78*
Poultry	*6.21*	*171.55*	*62.62*	*25.63*	*9.36*
Total	–	***551.43***	***201.27***	***150.53***	***54.95***

The reasonable volume of the fermenters provided the maintenance of the thermal mesophile regime, may be considered while evaluating the average production of biogas of 1 m^3/m^3 fermenter a day, that would signify the obtaining of about 45.16 thousands m^3 a day. In accordance with these calculations, and also from the effective of the great livestock complexes, it was estimated that the appropriated number of middle and large capacity fermenters (a reasonable volume between 100 and 800 m^2) utilizable mostly in the agricultural collective farms, is of about 90.

The sludge proceeded from the treatment plants. Nowadays 38 mechanical-biological treatment plants run in the Republic of Moldova. As a consequence of the economical crisis and of the water consume countering; these plants' capacity was almost twice reduced. But the sludge quantities proceeded from the handling of the wastewater, that now have an increased pollution rate with organic biodegradable materials, may be considered diminuend only with 1/3 in comparison with 1995, when these formed cca 267 t of d.s. per day [25]. At the specific debit of biogas of 0,33 m^3/kg d.s., it is possible to obtain about 60 thousands m^3 of biogas per year. For the efficient use of these capacities about 40-60 methane-tankers with a reasonable volume of the fermenters between 250-1,500 m^3 could be used.

The industrial wastewater. The wastewater proceeded from the food industry enterprises: alcoholic drinks and juice, canned goods, milk, sugar factories, are part of this category of industrial wastewater. Taking into consideration the fact that in 1995 only the anaerobic fermenting of the resulted from the mechanical-biologic treatment of the waste waters was possible at the treatment plants of the sugar and canned goods factories of the country, the estimated biogas quantity was of 121 thousands m^3/day [25]. Considering the economical situation, nowadays the potential of recovering the biogas from the industrial wastewater is of about 14.7 mil. m^3 per year. For its efficient use, 40 methane-tankers with a reasonable volume of 500-1,000 m^3 each would be necessary.

The municipal solid wastes. In accordance with the statistical data, during 1998 about 1,300 m^3 thousand of waste, including 700 thousands m^3 proceeded from the urban area, were collected aggregately and stored in special landfills and open dumps. The volume of the accumulated at the existent landfills and open dumps, in accordance with the estimations effectuated by the ecology inspectors, is of about 30 mil. m^3. Because most of the open dumps do not have authorization, being exploited with deviations from the technological demands, they can not be used for the methane recuperation. In the meantime, there are special sanitary landfills in the country those are being exploited for many years and the possibility of the methane recovering would be useful. The accumulated in the city of Chiєinгu MSW are evacuated to the Ювнюгreni's landfill, that had been exploited from 1991 till 2000, about 8 mil. m^3 being stocked here. In its turn the landfill from the city of Bгlюi has been exploited for about 30 years.

Nowadays, the launching of a separate collecting and/or sorting the MSW to the source program is necessary in the Republic in the purpose of organizing a centralized stocking and their recirculation. Later, in conditions of an optimal exploitation of the existent and new-made sanitary landfills, it will be possible to recover yearly about 3 mil. m^3 biogas per year.

Another channel of transforming the municipal solid waste in biogas is the "The Valorga Process" that consists of their anaerobic fermenting in wet state [26]. After the example of the installation of Tilburg (the Netherlands) and Amiens (France), cca 700 thousand tons of MSW that are yearly accumulated in the urban area can be treated. In this process, the average specific production of biogas is of 99 Nm^3/t MSW that result in maximum 69 mil. m^3 biogas a year. Of 1 m^3 of the fermenters it can yearly be obtained about 600 m^3 of biogas that leads to a demand of fermenting reasonable capacity of 115 thousands m^3. For the reasonable volume of 1,500,000 m^3 fermenter about 80 methane-tankers will be necessary.

II. Technologies and installation for the biomass use

The biomass use in the thermal energy production. The energy resources proceeded from the biomass *(wood and agricultural residues and municipal solid wastes)* are especially used by the little consumers of thermal energy. On this purpose generators of little output installations of thermal energy are exploited. They run both on the biomass consume and combined with other fossil fuels (*natural gases, coal and, seldom, on liquid fuels).* The simplest generating thermal energy installations are the stoves from the houses of the rural area. The greater consumers of the housing and industrial areas use for this purpose installations that consist of a thermal engine and a recovering boiler that produces both technological steam for industrial use and domestic and hot water for use in the housing area. As thermal engines of an output higher than 1 MW are usually used the gas turbines, and at lower outputs – internal combustion engines, in most of the cases Diesel type. As a rule the domestic refuses are burn in the hot water boilers of the small thermal power plants, but recently the CHPs are also used on this purpose. The rate of the boilers used at the power plants that run on wood, wood refuses agricultural residues and municipal solid wastes, and also combined with other types of fossil fuels is of about 75-92%.

The use of the organic residues in the obtaining the biogas by anaerobic fermenting. The technology of producing the biogas from the organic residues consists in its development in especially created conditions, in hermetic reservoirs named fermentation basins (methane-tankers), of some mix populations of micro-organisms, predominating the anaerobic bacteria, supplied with organic substances that are found in those residues.

The gaseous product of the metabolic processes, known under the name of fermentation or biogas, is formed, principally, of methane gas (CH_4) and carbon dioxide (CO_2), to which added smaller quantities of gases like the hydrogen (H_2), the sulfured hydrogen (H_2S), ammonium (NH_3) etc. There are two ways of recovering the biogas from the organic residues:

- The treatment of the organic matters at their stocking/producing place – in small individual installations;
- Their centralized treatment in large output installations.

a) The anaerobic fermentation of the animal manure

The existent installations are classified in the manner as follows:

- individual, of small and middle output;
- individual, of high output;
- collective, with the manure collection from the individual farmers.

Until the 80s of the past century, in most of the individual installations the generated biogas was used only for heating. Nowadays, in most of the cases, the biogas is used in the co-generation installations for producing electricity, with the heat recovering as a secondary surplus product, for heating the houses or the water. The biogas is stocked in reservoirs with a capacity of 60-100 m^3.

The overwhelming majority of the individual installations of middle and high output are constructed in accordance with individual design. A type of installation for the fermentation of the manure from 100 cows (Germany) costs around US$ 100 to 120 thousands. In Germany, the construction of this type of installations is subsidized in proportion of 20-25%. In this country the obtained from the biogas electricity can be sold at a price of US$ 0,10 per kWh. Besides, the co-generated biogas assures a yearly income of US$ 2 thousands from the heat recovering [21]. The animal manure collected from the farmers is used at the collective biogas installations. Such kinds of installations started to be used in 1985. These installations are fully used in Denmark. The Danish Agency for Energy initiated on this purpose a special program for constructing centralized biogas installations. The biogas from most of the installations is co-generated, the recovered heat being delivered to the municipal heating network. The running parameters of the most representative collective installations of Denmark are given below (*Table 3.13*).

Table 3.13. *The running parameters of 10 collective installations of Denmark [21]*

The volume of the fermenters, m^3/day	Animal manure, %	Organic residues, %	Thermal regime of fermentation, °C	Span of the fermentation, days	Biogas production, m^3/day	Use of the biogas
27	86	14	37	28	900	Heating
37	75	25	44	15	1,200	Delivered to the net.
44	63	37	37	34	4,400	Cogeneration
53	70	30	35	29	3,100	Cogeneration
58	73	27	56	15	4,500	Cogeneration
132	70	30	52	16	7,100	Cogeneration
152	77	23	37	21	7,100	Cogeneration
385	67	33	37	20	11,400	Cogeneration
402	84	16	53	12	11,800	Cogeneration
453	79	21	52	17	14,800	Cogeneration

The energy produced by 1m^3 of biogas costs US$ 0,28 in Denmark, and, when the gas is converted into heat and electricity, its price increases to US$ 0,42. About 30-35% of the total exploitation expenses are necessary for transporting the dejection and their collection. To balance them economically, the first collective installations needed substantial subsidies (30-40%), the new ones being subsidized in a 20% volume.

b) The anaerobic fermentation of the waste-water and of the sludge from treatment plants

Nowadays, for handling of the industrial wastewater that contain degradable organic components and pollutants, to neutralize them are implemented biological anaerobic methods, quite expensive because of the great consume of electricity to assure the anaerobic conditions of microorganisms growth. At the anaerobic fermentation of the used waters are produced important quantities of biological sludge, in which it is transformed 30-50% of the organic matter eliminated from the wastewater and that needs a further treatment, which is also expensive [23].

In comparison with the traditional technology of handling wastewater, at the anaerobic treating less energy and less biomass in shape of secondary sludge is consumed for maintaining the thermal regime in the fermentation basins. In this case about 4% of the submitted to biological decay organic matter is transformed in secondary sludge. The anaerobic fermentation is accompanied by the biogas emission that further may be used as a fuel [27]. This process is of a special interest not only as a renewable energy source, but also as a way of preventing the environment pollution.

Nowadays, the anaerobic fermentation is used mostly to find out the organic matter of the sludge from the localities' wastewater treatment plants, in methane-tankers, with the use of the suspended micro-flora [29]. The same technology is also frequently implemented in the anaerobic treatment of the industrial and domestic wastewater, though difficulties often appear when separating the suspended micro-flora for re-circulation [23, 29]. Lately, other technologies with fixed micro-flora use emerged [29,32], which are fully implemented in the treatment of the industrial wastewater with a high content of biodegradable organic matters, like those from the food industry, livestock, leather goods, etc. In this way, there is assured an efficiency of the biodegradable organic substance emission in proportion of 65-86% at the retention time from 0,2 to 3 days and in a cryophilic regime of alimentation (20 ^{0}C).

The handling of the wastewater leads to the retention and forming of important sludge quantities that include both the containing in the raw water impurities and the ones formed in the treatment processes. This sludge has an anaerobic treatment in the methane-tankers at the city and industrial wastewater treatment stations. The methane-tankers are hermetic fermentation basins that run in a mesophile thermal regime (~35 ^{0}C) or in a thermophile one (~55 ^{0}C), having installations to mix up, heat and collect the biogas, used as fuel in the individual or centralized thermal plants in the future [22, 28]. Usually, the emitted biogas quantity assures also the own necessities of the methane tankers to maintain the thermal regime of the sludge fermentation.

c) The anaerobic fermentation of the municipal solid wastes.

Of the anaerobic technologies of fermenting the municipal solid waste, we should mention the wet fermentation (the dilution of the residues with water until a humidity of about 90%) and the stocking of the residues with the future extraction of the biogas, using the wells, after an approximately 20 years' period.

The methane generating potential of the municipal solid waste sanitary landfills may vary between 62 and 125 m^3/ ton of dry substance. Of the accumulated in these landfills biogas quantity, from 50 to 90% of biogas may be recovered, depending on many factors, including also the distance between the wells and their depth, and also the permeability of the landfill covering layer [22]. In this way, in a period of 20 to 40 years of stocking, it will be possible to extract through the wells 2.5-12.5 m^3 of dry substance per year from the exploited landfills of solid domestic wastes.

The technology of wet fermenting the municipal solid wastes, known in the Western Europe as the "Valorga process", is especially used in France and Holland. One of the most representative installations (Tilburg, the Netherlands) (*Figure 3.7*) is running since 1944.

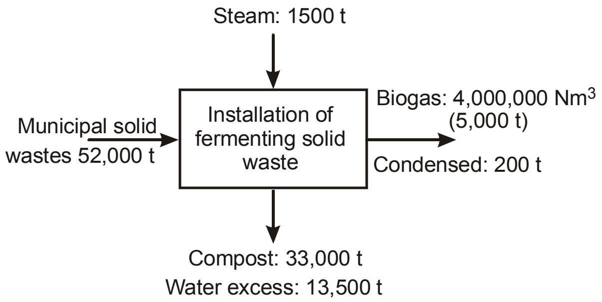

Figure 3.7. *The yearly material balance of the Tilburg installation [26]*

The municipal solid wastes containing 40-51% of dry substance, of which the organic substance makes up 36-60% and the inert particles (>0,5 mm) – about 5-11% of the dry substance, are submitted to fermentation at this installation. The main components of the municipal solid wastes are the municipal remainders (38%) and the garden residues (62%).

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4. TECHNOLOGY NEEDS ASSESSMENT
THE ABATEMENT OF THE GHG EMISSIONS IN ENERGY SECTOR

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4.1. The electrical power sector

In all the countries of the world, the power system constitutes one of the most important sources of GHG emission.

The volume of noxious emissions in general and particularly of the GHG emissions proceeded from the power system depends on:

1. The energy consumption of the county that, in his turn, depends on:
   - the level of the economical activity and its efficiency, characterized by the consumed quantity of energy for the production of an added value currency unit (energy intensity);
   - the mobility of the population, the utilized means of transport (railway, road, etc.) and their specific fuel consumption (kJ / (passenger · km));
   - the volume of the goods transportation, the utilized means of transport (railway, road, etc.) and their specific fuel consumption (kJ / t·km);
   - the consumption of energy resources for dwellings and water heating, food preparation, utilization of the electric appliances and air-conditioning equipment.
2. The way of meeting the electricity demand: by import or/and by constructing own thermal plants.
3. The applied technologies for the electric and thermal energy production, their efficiency and the used fuels.

Among the possible ways of these emissions' abatement, the rehabilitation of the utilizing fossil fuels installations is one of the most efficient steps. It seems that the problem is obvious and it only remains to make the rehabilitation. In fact, reaching the objective of reduction of the negative impact on the environment is quite difficult. First, the available resources for this effort are limited. That is why the rehabilitation must be implemented only where the result of the financial means capitalization will be the best.

The rehabilitation of the energy sector has two components:

1. The rehabilitation of the existing installations, with the following results:
   - The life-time prolongation.
   - The increase of the unitary capacity.
   - The passing from a fuel with increased carbon content to one with a decreased content, for example: from coal to natural gases.
   - The efficiency increasing.
   - The abatement of the GHG emissions.
2. Replacement of the plants that are at the end of their normative life time with new ones, based on up-to-date technologies.

Starting from the essence of these components, the problem of the GHG abatement may be tackled through two approaches:

1. The existing installations are analyzed each one separately with a viewpoint to their rehabilitation; for example, the approximately 3,921 thermal plants of the country could be examined each one separately with a view to establishing the opportunity and the efficiency of the rehabilitation works for the volume of emitted in the atmosphere harmful substances abatement;
2. The expansion of electricity sources (rehabilitation and construction of new plants) is analyzed in the complexity of how to meet the demand, for which they serve in the national economy ensemble; as an eloquent example may serve the examination of developing the electricity sources, having as candidate-plants both existing installations and new candidate-plants; it may happen that the rehabilitation of the existing plants will not resist economically the new plants, and if competitors appear, the volume of harmful emissions at the rehabilitated plants will certainly differ from the emitted volume in case if the plant that is going to be rehabilitated is examined apart from the other new candidate-thermal plants.

It is obvious that both approaches are right and that they must be selectively implemented, depending on each concrete case. But, anyway, all the available for rehabilitation existing technologies must pass through a previous selection process, before being examined more profoundly with a view to making the rehabilitation.

This selection is necessary because of the great number of rehabilitation candidate-technologies. The detailed evaluation of each of them would be expensive, because it would need too many financial resources, work and time.

With a view to making a preliminary selection, it is, of course, important to establish the criteria on which the respective selection will be done. First, the branches where the weight of GHG emissions is higher must be chosen. In the Republic of Moldova these are:

a) the electrical and thermal power sectors: the CHPs and the thermal plants (TPs);

b) the transport sector: road, railway, aircraft, naval;

c) the industrial sector: the industrial technologies, etc.

The further criteria on the basis of which the first choice of the candidate-technologies for the re-powering will be made must include: the age of the installation, the possibility of the rehabilitation, the type of used fuel, the running regime of the installation (present and future), the volume of GHG emissions in comparison with other installations, the extent degree of the installation to confirm the result, the viability of the enterprise that owns the installation, the viability of the further running of the installation, the location of the installation and its role in developing the energy sources, the general energy strategy of the country, etc.

If for the rehabilitation of the thermal energy sources it will be utilized with priority each source separate evaluation method, in case of the thermal plants, the examination of their re-powering possibilities will be done, in most of the cases, from the viewpoint of their running as part of a system.

4.1.1. Possible variants to meet the electricity demand

In order to identify possible variants of covering the electricity demand, an integral study, focussed on analysis and identification of the optimal variants of developing the electrical power sector for the period 2000-2030, has been made. In this study, the economical, political, strategic and other factors that could influence this process have been taken into consideration. Because of these reasons, in the process of identifying the developing prospects of the Republic of Moldova energy sector, capable to meet the electricity demand for the period 2000-2030, the following aspects had been estimated:

– Because the energy resources of the country are very limited, the covering of the electric and thermal energy demand is made either with own generation capacities that run on imported fuel, or by direct electricity import. The main source of the fuel and electricity import is the CIS (Commonwealth of the Independent States), especially Russia and Ukraine. In the future, the Republic of Moldova intents to diversify the energy sources because of strategic and energy security reasons.

– Initially, the electricity system of the Republic of Moldova was considered to run in inter-connection with the electricity systems of the CIS countries, especially with the Ukrainian one, with which it is connected through many large capacity inter-connection lines. Because of these reasons, at present, the respective system has only several inter-connection points, with low output, with Romania and Bulgaria, and, implicitly, with the similar systems of Europe.

– The production capacities of the electricity system are at the limit of the standardized span of life and have low efficiencies, adequate to the technologies of the moment when they had been built.

Taking into consideration these particularities, in the period 1998-2000, the Institute of Energy of the Academy of Sciences of the Republic of Moldova, with technical assistance from the International Agency for Atomic Energy (IAAE), made a study [1], aimed to identify the long-term meet of electricity demand possibilities. At present, this study is considered to be one of the most ample and truthful appreciation of the given sector. Out of these considerations, it has been utilized also in this paper, being up-dated to the 2001 conditions. The refreshed evaluations were made with the support of the computerized calculus software package ENPEP (ENergy and Power evaluation Program), elaborated by the National Laboratory Argonne (USA) and IAAE [2]. The forecast of the long-term electricity demand (2000-2025) was done by applying the MAED model (Model for Analysis of the Energy Demand) [3] of this pack, and the evaluation of variants and selection of the optimal one with the support of the WASP model (Wien Automatic System Planning) [4]. In this study, to identify *the covering the electricity demand possibilities* for the period 200-2030 *(Box 4.1*) the indexes of social-economic development of the country has been estimated, being analyzed nine possible variants of developing the power system.

In accordance with the made application assessments based on WASP model, only three of the nine estimated variants were identified as possible to the practical implementation, being considered as assuring a sustainable development of the power system. The identified variants are:

Variant 1, generically named *"Import"*, that supposes:

- the re-powering of some existing plants (without construction of new production capacities);
- the import through the existing inter-connection lines and through new lines that are to be constructed.

Variant 2, named "*Self-sufficiency":*

- the re-powering of some existing plants;
- the construction of capacities based on gas turbines as well as the combined cycle units on natural gases;
- a decreasing tendency of the electricity import;
- participating in the finalizing the U2 generation unit from NPP Cernavoda (Romania) with an installment of 200 MW (after 2008).

Variant 3, named "*Development without imposed conditions*", makes up an intermediate option, based on the following principles:

- the re-powering of some existing plants;
- the construction of capacities based on gas turbines and groups with combined cycle of different output capacities;
- the import of electricity in the convenient economic conditions through the existing inter-connection lines and through new ones;
- participation in the construction finalization of the energy unit U2, NPP Cernavoda with an installment of 200 MW (after 2008).

Box 5.1. *The main subjects for public debates concerning the EU security of the energy supply*

1. What should the EU strategy be in the conditions of the increasing external energy dependence?
2. What policy must be adopted in the EU for the liberalization of the energy market?
3. What roles do the fiscal system and the State support have to play?
4. What kind of relations should be maintained with the countries-producers of energy resources?
5. What kind of policy should be adopted concerning the energy stocks?
6. How could be strengthen the energy supply networks?
7. What support must be given to the implementation of the renewable energy sources? Must the traditional energy sources be utilized for these supporting activities?
8. How could the EU participate in finding a solution to the wastes, nuclear security fortification and the development of the analysis concerning the future reactor problems?
9. How should EU combat the climate change phenomenon? What role does the energy economy have?
10. Is it necessary to adopt a communion policy in the sector of the bio-fuels? What would its essence be?
11. Is it necessary to utilize incentives or special regulations for the energy economy in the buildings?
12. What would be the way to encourage the substitution of the fuels for stimulating the energy and transport economies? What steps must be taken for the passing of the goods that are transported by automobiles to the railway, and to reduce the automobiles circulation in the cities?
13. How could EU, the member States, the regions, the producers and the consumers contribute to the development of a long-term system of energy supply? What should the energy options of the future be?

Taking into consideration the current state of the energy sector (the ages of the equipment, the technical state and its productivity), economically, the rehabilitation of a limited number of existing plants had been considered timely. In this way, in the present study, it had been estimated the installation of gas turbines at the thermal plants Munceşti and South, the extension of the CHP-North Bălți and CHP-1 Chişinău (*Table 4.1*). Republic of Moldova's participation in the construction of Cernavoda NPP (România) installing had been taken into consideration because the given problem was being examined at the day of the study elaboration.

For given study period, the new electricity generation units installation has been foreseen and estimated with a view to replacing the quashed groups (after outrunning the "standardized life span") and to install new capacities. These units

Table 4.1. *The possible rehabilitation of some plants*

The plant \ Indexes	Specific investments USD / kW	Capacity, MW	Cost of electricity, US$/MWh	Maximal no. of units
GTI at TP Munceşti	*453*	*6*	*27.50*	*1*
Extension CHP-1	*851*	*12*	*46.05*	*4*
Extension CHP-North	*661*	*10*	*45.40*	*3*
GTI at TP South	*411*	*20*	*34.97*	*3*
New GTI in Bălți	*400*	*37*	*35.69*	*2*

are represented by gas turbines of different unit capacities (51-115 MW), proceeded from different constructors (Rolls-Royce, Westinghouse Electric and ABB) with different technical and economical features. At the same time, it was foreseen the installation of the combined cycle units with unitary capacity between 111-238 MW, produced by the Stewart/Stevenson, Westinghouse Electric and Siemens firms, and having also different technical and economical features (*Table 4.2*).

Because the economically justified share of the electricity import depends on its price, the following price scenarios were estimated: US$/MWh 35, 40 and 50. The electricity import necessity was evaluated on the whole with the re-powering of some existing installations and putting into operation some new units options.

The possibilities of electricity import through the inter-connection lines from the West and South-West of the Republic of Moldova are limited and, in the future, they will be tightly connected with the extension to East program of the UCTE (Union for the Coordination of the Transport of the Electricity). After Romania and Bulgaria' admissions in UCTE, the Republic of Moldova will be able to import electricity from the country-members of this Union by implementing one of the technical solutions:

– synchronous supply of some areas of the Republic of Moldova through the inter-connection with the Romanian and Bulgarian electricity systems;
– asynchronous supply through the "back-to-back" direct current station that could be installed in Isaccea (Romania).

Out of these considerations, in the variants 1 and 3, where the electricity import could have a considerable share, investments of about US$ 100 are needed for the following actions:

– Reinforcement of the internal network on the direction Vulcăneşti–Chişinău. This would allow the transit of the electricity, imported from Romania and/or Bulgaria or from other members of the UCTE electricity systems, to the Chişinău area through "back-to-back" station from Isaccea and the 400 kV line Isaccea–Vulcăneşti. For this purpose, by 2005 investments of US$ 62.5 mil. will be necessary;
– Construction of a 400 kV interconnection line with Romania that have to be operational when the electricity system of the Republic of Moldova will be able to run simultaneously with the UCTE systems (US$ 37.5 mil. by 2010).

After estimating how to meet the long-term electricity demand, a calculus, that had the purpose of identifying the *optimal variant*, had been made. The given study had been realized with the support of the WASP model. For this purpose, all three variants have been evaluated economically, according to the discounted total cost criteria (*Box 4.2*).

Box 4.2. *The indexes in the electrical power system development variants taken into consideration*

– The minimal discounted total cost optimization criteria.
– The system power capacity reserve in the limits of 10-40%.
– Discounted rate – 10% yearly.
– The forecast of the energy demand was based on expected social-economic development of the Republic of Moldova, in the conditions of a pre-established evolution of the energy import.
– The implementation of the decommissioning the existing own plants plans and the construction of inter-connection lines with the neighboring with the Republic of Moldova energy systems.

Referring to the studied variants, the following conclusions may be taken from this study:

For variants:

Variant 1, "Import" - supposes to meet the electricity demand with priority by imported energy (*Figure 4.1*). It is being implemented through the current import from Ukraine, Russia,

Table 4.2. *New candidate groups in the electricity power sector*

Units \ Indexes	Specific investments, US$/kWi	Capacity, MW	Net efficiency, %	Cost of electricity*, US$/MWh
ITG Rolls-Royce**	*562*	*51*	*41.6*	*32.23*
ITG Westinghouse Electric**	*430*	*86*	*36.6*	*33.43*
ITG ABB**	*340*	*115.5*	*34.9*	*33.44*
ITGA Stewart&Stivenson**	*888*	*111*	*53.3*	*32.95*
ITGA Westinghouse Electric	*576*	*179*	*51.9*	*29.59*
ITGA Siemens**	*575*	*238*	*52.1*	*29.53*

* - Cost of electricity leveled for the life-time period and determined for the maximal load of the unit without taking into consideration the load curve;

** - Name of the firm-manufacturer is given for exemplification. Similar installations of any other firm may be used for rehabilitation.

Romania and the deliveries of the Moldovan TPP, enlarging the possibilities of import though the existing and new inter-connection lines; the rehabilitation of some production capacities; the local energy production has a more reduced role, especially after 2015.

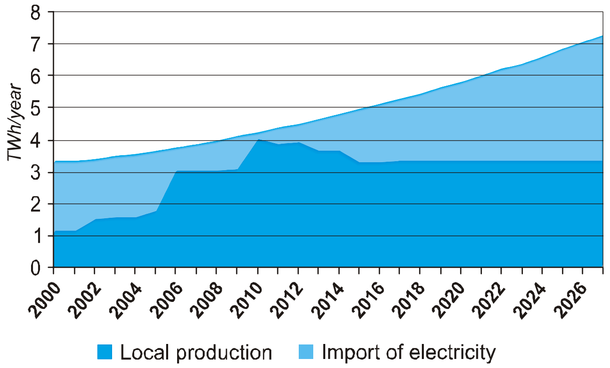

Figure 4.1. *The share of different sources meeting the electricity demand for Variant 1 "Import"*

Variant 2, "Self-sufficiency", supposes to meet the electricity demand by its production at a national level and by import, giving the priority to the development of the local sources (*the growing electricity demand up to 2012 will be met from the own energy sources*) (*Figure 4.2*). This variant is implemented through the construction of own plants, including those of new capacities, endowed with gas turbines installations (GTI) and units with combined cycle on natural gases (GSTI) of different capacities, as well as through the re-powering of some existing plants (*Box 4.3*). It is important to mention here the fact that, for this program, the whole fuel volume needed for electricity production, mainly natural gases, will be imported from a single source in the future. The import has a decreasing tendency in comparison with the variant 3.

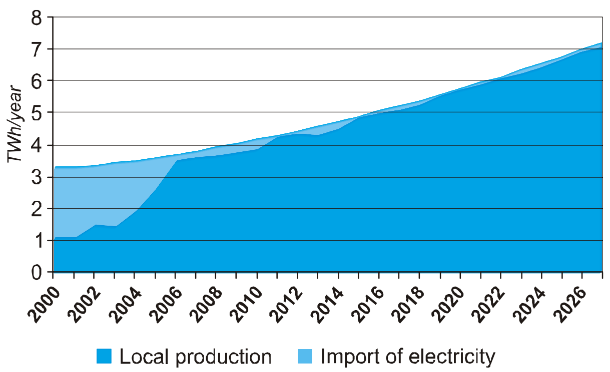

Figure 4.2. *The dynamics how the demand will be met in Variant 2, "Self-sufficiency"*

Variant 3, "Developing without imposed conditions" – it is implemented by covering the electricity demand through the free competition of the energy import and its production by the own sources (*Figure 4.3*) (*the option that a considerable part of energy could be imported from the West, assuring in this way a higher energy security, had also been taken into consideration*). This variant is implemented through the re-equipment of some existing plants; through the construction of gas turbine installations (GTI) and combined cycle installations on natural gases (GSTI-CCGT) of different capacity (*Box 4.3*).

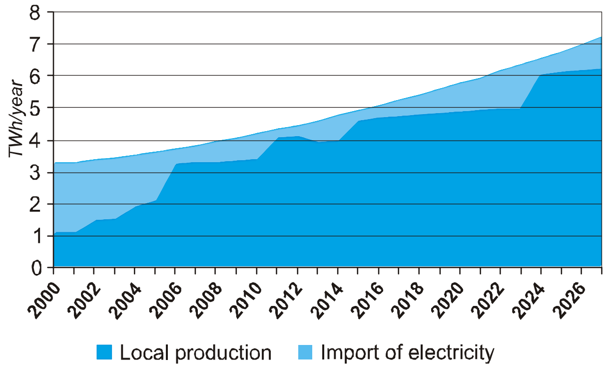

Figure 4.3. *The dynamics how the demand will be met in Variant 3 "Development without imposed conditions"*

Box 4.3. ***Re-powering considered in power system development variants***

– The rehabilitation of the existing plants:

a) Installing gas turbines at the TP Munceşti and TP South.

b) Installing gas turbines at CHP-North Bălți.

– Installing gas turbines combinations of 51 MW, including the combined cycle units of total 179 MW.

– Participating in the construction finalization of the U2 generating unit from Cernavoda NPP with an installment of 200 MW (in case if the investments will not exceed US$/kW 1,500).

For technical and economical indexes of the variants:

a) Discounted total cost of the power system:

It is observed that:

– Variant 3, "*Development without imposed conditions", supposes the most reduced discounted total cost determined for the whole study period. As the estimations showed, this result is maintained regardless of the price of the imported electricity forecast (*Table 4.3).*

– Variant 2, "*Self-sufficiency*", the discounted total cost higher than in case of the third variant, determined by the necessary investments for a more dynamic trend of the local sources construction (*Table 4.3).*

Table 4.3. *The discounted total cost of power system expansion for the period 2000-2025, US $ mil.*

Variant	Imported electricity price		
	35 US$ / MWh	40 US$ / MWh	50 US$ / MWh
Variant 3	*1242*	*1245*	*1250*
Variant 2	*1262*	*1263*	*1264*
Variant 1	*1303*	*1372*	*1510*

– Variant 1, ("*Import*"), based on massive electricity import and on the re-equipment of some existing plants, in comparison with other examined variants, it is one of the simplest option to meet the energy demand during the study period (*Table 4.3*).

In the analysis of this total cost difference, we also must refer to the fact that the Variant 3 (the cheapest one) contains also the costs for the electric network reinforcement, that are not presented in the Variant 2. If the necessary costs for the larger electricity imports from the West and South-West and for the preparation the energy sector of the Republic of Moldova for the admission to the UCTE has been taken into consideration, the cost difference between the two variants would have been even greater.

b) "Discounted investments cost":

– Variant 1, "*Import*", needs the lowest investments, necessary only for the re-equipment of some existing installations (*Table 4.4*).

Table 4.4. *The discounted total need investments, US $ mil.*

Variant	Period	Imported electricity price		
		35 US$/MWh	40 US$/MWh	50 US$/MWh
Variant 3	2000-2012	*179*	*179*	*182*
	2000-2025	*214*	*215*	*223*
Variant 2	2000-2012	*204*	*204*	*204*
	2000-2025	*255*	*255*	*255*
Variant 1	2000-2012	*50*	*50*	*50*
	2000-2025	*50*	*50*	*50*

– The maximal investments are necessary in case of the Variant 2, "*Self-sufficiency*", as the investment effort comprises a middle period (2000-2010).

– In this aspect, Variant 3 "*Development without imposed conditions*", supposes intermediary investments between the variants 1 and 2.

c) "Electricity import".

The electricity import for coming decade varies between 12.3 TWh (for the electricity import price of US$ 50/MWh from the Variant 2) and 35.0 TWh (for the electricity import price US$35/MWh from the Variant 1). For the entire study period (2000-2025) the given index has comprised between the limits 14.3 TWh (US$ 50/MWh – Variant 2) and 110 TWh (US$35/MWh – Variant 1).

d) "Average electricity cost for the study period**".**

This indicator represents the ratio of the discounted total cost of the system expansion and to the sum of discounted yearly quantities of electricity over the period of study. It varies between US $ 30,1/MWh (in the Variant 3, for the import price of US$ 35/MWh) and US$ 36,53/MWh – in the Variant 1, for the import price of US$ 50/MWh (*Table 4.5.)*. The price of US$ 30,1-30,6/MWh, feature for the variants 1 and 2, could be used in the future as an acceptable variant of the price for the offered by the new independent energy producers of electricity and as a reference price for the import contracts.

Table 4.5. *Average electricity production price, US$/MWh*

Variant	Imported electricity price		
	35 $SUA/MWh	40 $SUA/MWh	50 $SUA/MWh
Variant 3	*30.00*	*30.07*	*30.27*
Variant 2	*30.56*	*30.57*	*30.60*
Variant 1	*31.52*	*33.20*	*36.53*

After an integral analysis of the possibilities to meet the electricity demand for the period 2000-2030, it was concluded that the Variant 3 ("*Development without imposed conditions")* means an optimal way of developing the electrical power system of the Republic of Moldova. The main arguments in support of this option are:

– The respective variant entails the lowest discounted total cost for the expansion over the entire period of study.

– It is a balance of electricity import, re-powering of some existing installations and the construction of new capacities (gas turbines of 51 MW and combined cycle groups of 179 MW).

Because of the technical and economical impossibilities to participate in the construction of the U2 energy unit of Cernavoda NPP, in the given variant, this was substituted with a supplementary combined cycle type group (see the share of the new candidate thermal plants in covering the electric loads for the case of energy import at the price of US$ 35/MWh (*Figure 4.4*).

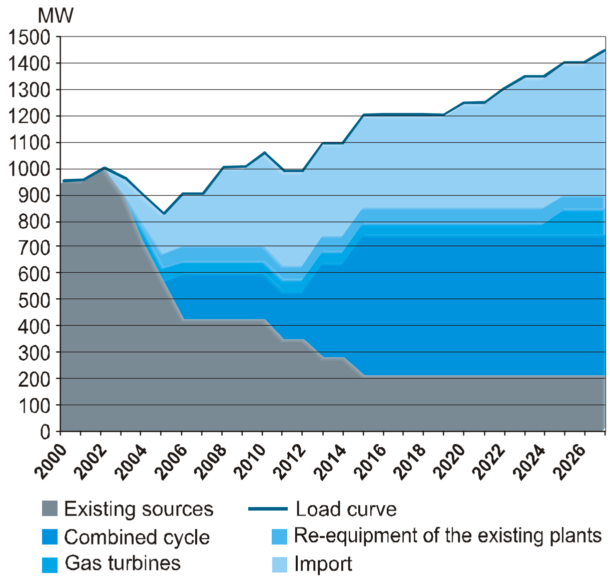

Figure 4.4. *The quota of the existing sources, the new candidate plants and the import in meeting the electric demand for Variant 3 ("Development without imposed conditions")*

- It allows to fulfill the required conditions for connection of the energy system of the Republic of Moldova to UCTE system by reinforcing the interconnections to West and the internal network on the South-North direction.
- It assures a high energy security of the country.

4.1.2. Scenarios of GHG emissions abatement through the rehabilitation of the electrical power system

As we established above, the variant 3 *"Development without imposed conditions"* was considered as an optimal model for developing the electrical power system of the country for the analyzed period (2000-2030). The economical, technological and financial features of this variant supposes a favorable, most significant effect for the environment. Out of these considerations, the given variant served as a basis in the evaluations concerning the abatement of the GHG emissions through the rehabilitation of the electrical power facilities.

To evaluate the possibilities of the GHG emissions abatement, the existing in this system alternatives, at a world scale, had been estimated:

- The energy economy, taken into consideration aspect in the electricity demand estimation in the three variants of developing the electricity sources.
- Passing from the thermal and electricity production by combusting fossil fuels to other energy forms without or with a reduced carbon content, as: hydro, solar, wind, biomass, nuclear. In this aspect, it is being estimated that, in the future, their weight in the meeting of the energy demand of the Republic of Moldova will be still reduced.
- The utilization of some techniques for the selective retention of the GHG emissions from the combustion gases.
- The replacement of the present old and inefficient technologies of electricity production and consumption with technologies that have an increased energy efficiency.

Taking into consideration the above aspects, on the basis of the Variant 3 three *Scenarios to meet the electricity demand, which include, also, options for the GHG emissions*, have been elaborated. The main options of these scenarios are:

a) The electricity production efficiency has the following values – 38, 42 and 52%.
b) The investment costs of the power plant rehabilitation corresponds to the considered efficiencies.

The scenarios for the proceeded from the electricity production system GHG emissions reduction may have the following characterization:

- **The High alternative scenario (HAS)** represents an optimal scenario for the development and functioning of the electricity power system of the Republic of Moldova, with minimal total discounted prices and maximal total investments. This proposes a balanced structure of the own sources and of the electricity import, assuring a high security and a maximal level of the GHG emissions abatement. The respective scenario for the reduction of the GHG emissions is nearly similar to the options of the Variant 3, previously analyzed. The only difference between these two models is the exclusion of the Republic of Moldova's participation in the finalization of the U2 unit from Cernavoda NPP option, which is not up-to-date anymore, from the HAS scenario model. This has been replaced with the option of developing the energy power system by constructing combined cycle gas-steam groups (GSTI), proceeded from different constructors (Westinghouse Electric, Siemens, Stewart & Stevenson) with a technical rate of 52%, using natural gases as a fuel.

- **The "Base-line scenario" – BLS.** This scenario does not mean to encourage or to need undertaking of any actions for the GHG emissions abatement programs or policies. The stipulated in the scenario activities will have as objective the maintenance of the present power system. The new groups, with a little improved rate (about 38%), on natural gases consumption, will replace the groups that are going to be quashed at reaching the "standardized life span" and will serve for covering the energy deficit, appeared as a result of the load increase. Methodologically, this scenario serves as a reference scenario for comparing the degree of GHG emissions abatement after the rehabilitation.
- **The "Intermediary scenario" – IMS.** In case there is no any adequate financial support for the implementation of the HAS scenario, alternative options, with a different degree of re-powering, may be considered. From the different alternatives in this aspect, we made our opinion for a scenario that stipulates the rehabilitation of several existing installations, as well as the construction of installations with an efficiency of 42%. The rehabilitation will have to be implemented where the limited financial resources can be capitalized the best, the GHG emissions abatement being also one of the main criteria of appreciating the way of capitalizing.

The three scenarios could be characterized individually or compared through the following criteria:

(a) Discounted total cost (DTC for the development and functioning of the power system over the study period;

(b) Total GHG emissions;

(c) GHG emissions per capita and per GDP unit;

(d) The evolution of the yearly GHG emissions during the study period.

This tackling allowed the characterization of the HAS and IMS scenarios through the utilization of the *GHG emissions volume and price* indexes in comparison with the BLS scenario. In this way, by applying the IMPACTS model of the ENPEP software pack, the level of the GHG emissions has been determined for each analyzed scenario (HAS, IMS, BLS) (*Figure 4.5.*). It was concluded that *the volume of the emissions is reverse proportionally to the efficiency of the implemented in the re-equipment process technologies.*

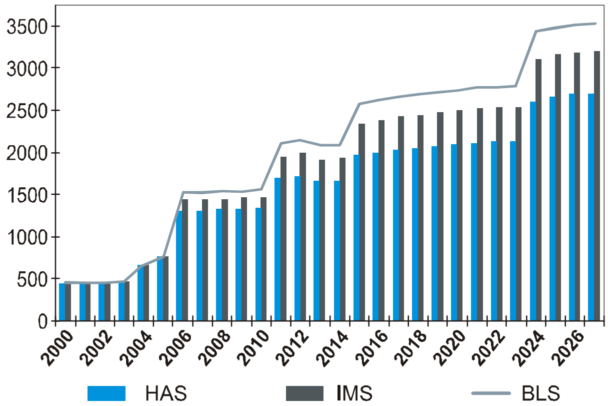

Figure 4.5. *The evolution of the direct GHG emissions for the HAS and IMS abatement scenarios in comparison with the base-line scenario – BLS, Gg CO_2 equivalent*

Considering the main technological and economical indicators that characterize the power system of the country, the degree of the GHG emissions after re-powering has been evaluated (*Table 4.6.*).

It had also been established that the volume of the GHG direct emissions is tightly depending on such parameters of the abatement scenarios like: the efficiency of the technologies, the total investments and the discounted total cost (*Figure 4.6*).

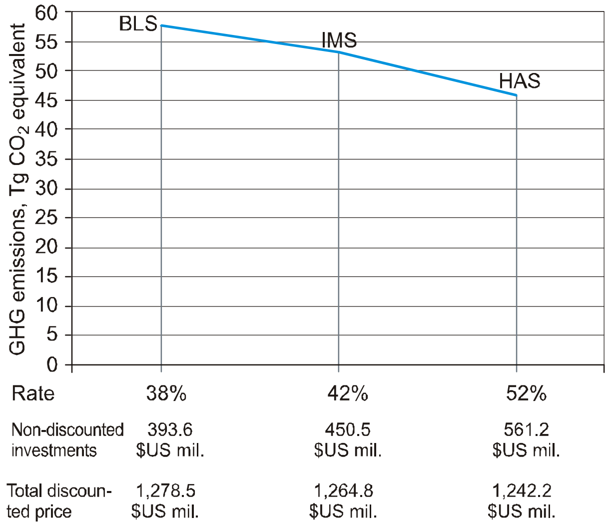

Figure 4.6. *The dependence of the direct GHG emissions of the rate of the technologies, the total non-discounted investments and the discounted total cost of the re-equipping the electrical power sector scenarios*

Table 4.6. *The technico-economical and GHG emissions abatement indexes for the BLS, IMS and HAS scenarios*

Parameters		Measure unit	HAS	IMS	BLS
Discounted total cost (DTC)		US$ mil.	*1,242.2*	*1,264.8*	*1,278.5*
Total non-discounted investments		US$ mil.	*561.23*	*450.45*	*393.6*
Non-discounted cost of the fuel		US$	*1,935.1*	*2,201.4*	*2,383.6*
Re-powering at TP Munceşti Chişinău	Efficiency	MW	*6*	*6*	*6*
	Number of units	Units	*1*	*1*	*1*
	Specific investments	US$/kW	*453*	*453*	*453*
	Installed capacity	%	*76.7*	*76.7*	*76.7*
Re-powering at CHP-North Bălți	Efficiency	MW	*10*	*10*	*10*
	Number of units	Units / year	*1*	*1*	*1*
	Specific investments	US$/kW	*661*	*661*	*661*
	Installed capacity	%	*38*	*38*	*38*
Re-powering at CHP-1 Chişinău	Efficiency	MW	*10*	*10*	*10*
	Number of units	Units / year	*1*	*1*	*1*
	Specific investments	US$/kW	*550.5*	*550.5*	*550.5*
	Installed capacity	%	*38*	*38*	*38*
Re-powering at TP South Chişinău	Efficiency	MW	*20*	*20*	*20*
	Number of units	Units / year	*1*	*1*	*1*
	Specific investments	US$/kW	*411.1*	*411.1*	*411.1*
	Installed capacity	%	*37*	*37*	*37*
The construction of new candidate combined cycle units	Efficiency	MW	*179*	*179*	*179*
	Number of units	Units / year	*1x2006 1x2011 1x2015 1x2024*	*1x2006 1x2011 1x2015 1x2024*	*1x2006 1x2011 1x2015 1x2024*
	Specific investments	US$/kW	*580*	*420*	*340*
	Installed capacity	%	*52*	*42*	*38*
Construction of new gas turbine units	Efficiency	MW	*51*	*51*	*51*
	Number of units	Units / year	*1x2004*	*1x2004*	*1x2004*
	Specific investments	US$/kWi	*562*	*562*	*562*
	Installed capacity	%	*42*	*42*	*42*
Volume of GHG emissions (CO_2 equivalent)		Tg	*45.8*	*53.1*	*57.6*
Reduction of direct GHG emissions, which amounts to 1% of the efficiency increase in the comparison of the re-equipment HAS-BLS scenarios (VGES_BLS- VGES_HAS)/(ηHAS-ηBLS)		Tg direct GHG emissions/1% rate	*0.84*		
Reduction of direct GHG, which amounts to 1% of the efficiency increase of the re-equipment comparison IMS-BLS scenarios (VGES_BLS- VGES_IMS)/(ηIMS-ηBLS)		Tg direct GHG emissions/1% rate	*1.125*		
Reduction of the direct GHG emissions, which amounts to 1% of the investment increase in the rehabilitation, in comparison with HAS-BLS scenarios (VGES_BLS- VGES_HAS)/(IHAS-IBLS)		kg direct GHG emissions/ US$ 1	*70.4*		
Reduction of the direct GHG emissions, which amounts to 1% of the investments increase in the comparison IMS-BLS scenarios (VGES_BLS- VGES_IMS)/(IIMS-IBLS)		kg direct GHG emissions/ US$ 1	*79.15*		
Reduction of the direct GHG emissions, which amounts to 1% of DTC decrease in rehabilitation,in comparison with HAS-BLS scenarios (VGES_BLS- VGES_HAS)/(CTAHAS-CTABLS)		kg direct GHG emissions/ US$ 1	*325.1*		
Reduction of direct GHG emissions, which amounts to 1% of DTC decrease in rehabilitation, in comparison with IMS-BLS scenarios(VGES_BLS- VGES_IMS)/(CTAIMS-CTABLS)		kg direct GHG emissions/ US$ 1	*328.5*		

As a result of the study, effectuated with a view to establishing the optimal scenarios for the GHG emissions abatement through the re-powering of the electricity production facilities, we put the conclusions as follows:

(a) The Variant 3 "*Development without imposed conditions*" has been identified as an optimal model of developing the electricity production sources of the country for the period 2000-2030.

(b) Because the economico-financial and technological features of the Variant 3 suppose a benefic result of maximal amount for the environment, on the basis of this variant, three scenarios of covering the electricity demand (HAS, IMS and BLS) that include also options of the proceeded from the electricity generation GHG emissions abatement, have been elaborated.

(c) The fundamental options of these scenarios are the efficiencies of electricity production through new technologies, at the technical amounts of 38, 42 and 52%; the total investment cost and a respective level of the GHG emissions abatement, corresponding to the three rates and to the policies that are fated to encourage the carry out of actions for the GHG emissions abatement.

(d) The HAS scenario has been considered as an optimal scenario for the development and operation of the electricity power system of the Republic of Moldova, as it proposes a balanced structure of the own forces and of the electricity import, assuring a high energy security and a maximal abatement of the GHG emissions.

The comparison of the analyzed scenarios allowed the emphasis of the following aspects:

– in comparison with the base line scenario – BLS, the implementation of HAS scenario will lead to a 2.8% reduction of the discounted total costs and will allow, simultaneously, a reduction of the total volume of direct GHG emissions with about 20%;
– in comparison with the BLS scenario, the alternative scenario – HAS and IMS – in the condition of the Republic of Moldova, allow obtaining a reduction of the GHG emissions of 70-80 kg CO_2 equivalent to each USD invested;
– each percentage of increasing of the modified technological equipment rate intermediate the re-equipment contributes to the reduction of the total direct GHG emissions in a volume of 0.84-1.125 mil. tons for the analyzed period.

4.1.3. Aspects concerning the re-powering promotion in the electricity production sector

The future policies and programs, initiated with a view to encouraging the activities for the reduction of the GHG emissions will have to take into consideration the following aspects.

Until initiating the privatization of the production and distribution electricity companies in the Republic of Moldova, the responsibility for developing the electricity sources, as well as for assuring the consumers with electricity, was an exclusive prerogative of the state. It is well-known the fact that, at present, there is an electricity market in the Republic: three of the five electrical distribution network enterprises (EDN) were privatized by the Spanish Company Union Fenosa, and other two are in privatization process. It is also being intended to privatize the electricity production sources; the distribution companies – both the state and the private ones – are licensed to supply electricity at settled rates, negotiate independently the acquisition of the electricity from the power plants and the independent suppliers. So, the assurance with electricity is being effectuated through market mechanisms.

In spite of all these, the consumers do not have the right to choose the energy suppliers yet. The responsibility for developing the sources lies with the electricity suppliers, at settled rates. The suppliers are supposed to come with the initiative concerning the construction of some power plants, presenting the following arguments:

1. It is impossible to assure the consumers with energy from the existing sources (import or from the domestic power plants).
2. The electricity price from the currently utilized sources is higher than the price of the produced energy at the power plants that would be constructed on the country's territory.

The National Agency for Energy Regulation (NAER) is the only structure that settles the electricity market of the Republic of Moldova. It has the authority to observe the correctness of this process.

Both in the first (the initiative that comes from the supplier at settled rates) and the second case (the initiative that comes from NAER), the electricity suppliers will conclude long-term contracts with the new plants, selected as a result of an international tender, at settled rates, having as an objective the electricity production at a as low price as possible [1].

Having an energy demand on the market, which is not met by the existing energy sources at a reliable level and at an adequate price, the investors would be able to construct electricity generating sources, having the status of power plant with independent regime of operations on the market. These could be attractive also for the eligible consumers (which have the right to sign direct electricity delivering contracts), that will appear on the market with NAER's permission.

Out of the related above, we conclude that the implementation of one or other developing the electricity scenarios, can not be effectuated through a simple State intervention, but in accordance with the energy market functioning regulation, that has as a major objective the maximal reduction of the delivered to the beneficiaries electricity.

As a conclusion, we emphasize that the re-powering of electricity production facilities is one of the most efficient way that assures the abatement of the GHG emission. But these must be performed by taking into consideration the economical, political, strategic factors, movement towards a competitive market, etc. The problem of the GHG emissions abatement is very complicated and must be tackled very attentively, especially in the electricity sector, where the power plants are functioning in a whole system.

4.2. The thermal power sector

The main features of the thermal power sector in the Republic of Moldova was and continues to be the high degree of centralization (in different localities of the country this index varies between 0,4-0,85). The main thermal energy sources are the district- town-enterprise thermal plants (TPs), and in municipals – the combined heat and power production plants (CHPs). Though the centralization is considered a positive factor in supplying with thermal energy, many of the existing heating systems have a non-rational structure (the heat sources are located far from the center of the consumption, the networks have exaggerate lengths, and for assuring the necessary pressure to the consumers intermediary pumping stations are implemented). Besides, the domestic thermal-energy sector has a number of other drawbacks, as: the low level of the combined heat and power production, high degree of physical wear-out of the equipment, non-utilization of the local fuels and of the renewable energies, etc. To all these difficulties, in the last period, a drastic reduction of the thermal energy demand, and the insolvency of a large part of the consumers has added.

At present, the main drawbacks of the thermal energy sector, which have to be removed without delay, are: the low quality of the performed services and the exaggerate tariffs for the delivered thermal energy.

The low quality of the thermal energy supply service (the non-adequate temperature level of the thermal carrier, the frequent disconnections of the hot water supply systems, the belated connection and the before-time disconnection, the lack of an adequate temperature regulation in the heated rooms, etc.) represent the main causes of the solvent consumers giving up the centralized heat supply system.

Because of the fossil fuels own resources deficiency, the Republic of Moldova is compelled to import these resources at world prices, and, sometimes, even higher, that, alike with the inefficient utilization of the fuel and below any level management, generates costs that cannot be paid by the majority of the consumers.

For the bettering of this situation, besides a number of steps for the reorganization of the systems by de-monopolizing and privatizing them, legislative steps, having as a purpose the drawing of the investments and the increase of the branch efficiency, the optimization and rationalization of the thermal energy supply systems, and the re-equipment of all the segments of the thermal-energy sector. So, we refer to:

– the thermal energy generating sources;

– thermal networks;

– installations for the thermal energy utilization.

The rehabilitation will be, along with the main factor that will better the thermal-energy sector impact on the environment, establishing both the noxa and the GHG emissions reduction.

4.2.1. Re-powering of Thermal Energy Generation Sources

Rehabilitation of existing heat sources aims at increasing the efficiency of fuels use or replacing fossil fuel with renewable energies (solar, wind, water, geothermal, biomass, municipal and industrial wastes). The re-equipment, aimed at diminishing the GHG emissions, is also carried out by moving boilers from burning fuels with high carbon content to other sources with less carbon content. As the share of fuels with high carbon content (coal and residual heavy oil) is insignificant in our country, if compared to combustible gases, a tremendous effect has been already achieved in such a way. There can be obtained an efficient use of both fossil and non-fossil fuel if:

- boilers with high efficiency are used;
- co-generation is applied;
- heating pumps are used;
- fossil fuel is substituted by biomass and other renewable energies are used.

CO_2 emissions resulting from biomass burning are regarded as null, because the same quantity of the foregoing gas will be emitted during the natural biomass decomposition.

I. Boilers rehabilitation

A great share of boilers at the existing thermal plants, especially the ones of low and medium productivity, set up during the 60s-70s of the last century, are produced by an outdated technology, having a low efficiency. Thus, boilers of "Universal", "Minsk", "Tula" types have a gross efficiency for solid fuels burning of 0.62-0.64, and for natural gas burning - 0.7-0.8. Real efficiency is much more inferior. These boilers are installed in TPs, which serve local centralized heating systems. In localities supplied with natural gas, if such TPs are substituted by autonomous systems with modern boilers, the fuel will be used much more efficiently. There are other means to augment boilers' energy efficiency. For instance:

- Placing boilers within the served buildings, we can avoid both heat losses in networks and boiler's heat losses in the environment, which are over 5% for small boilers.
- High quality modern burners, air pre-heating at some boilers, its ionization at others almost totally diminishes losses with chemically incomplete combustion.
- Stainless boiler operation excludes the threat of corrosion while cooling under the temperature of dew point, thus allowing use of latent heat of vapor condensation in burning gases.

As a whole, these factors raise the real efficiency value of the use of combustible gas burning heat up to 95%. The high degree of automation allows individual systems of heat supply to function on the basis of modern boilers with no attending staff. Small, state-of-art boilers of the thermal plants can also consume light liquid fuel (light fuel products), but the cost of energy in such a case will be much higher.

II. Cogeneration

Electric and thermal energy cogeneration constitutes the most efficient method of fuel consumption reduction in the energy sector. During the cogeneration, the thermal energy partially represents waste of electric energy production. In the case of separate production power plants have an efficiency of 35-50%, while the total efficiency of combined heat and power plant amount to 75-90%. High CHP efficiency resulted in their intensive spread in industrialized countries. Thus, in Denmark in excess of 50% of electrical energy is produced through cogeneration [5], in the Netherlands - 35%, in Finland - 30% of the electric energy and 75% of the thermal one [6]. There are built both huge plants, with electric power of 300-500 MW (on the basis of gas turbines and steam turbines), and small installations of 0.05-10 MW, based on gas turbines or Diesel engines with internal combustion [5,7].

It is worth mentioning that in the case of CHPs, the efficiency is not an absolute feature of the effective use of fuel's prime energy. In such a case another index is used, and namely "fuel saved in comparison with separate production of the same quantities of energy (electric and thermal)" (Box 4.4). Besides the global efficiency, the fuel saved depends on the ratio of electric power to the thermal one, as well as on the ratio between the respective quantities of energy produced.

Box 4.4. *Fuel saved in comparison with separate energy production at CHPs*

For global efficiency in excess of 90%, large modern CHPs have an electric efficiency of 45-47% and can assure fuel savings, in comparison to separate production, up to 80%. For small-scale CHPs it is possible only a saving of 20-50%.

For instance in the Republic of Moldova in 2000, CHP-2 of Chişinău, with a lower global efficiency than the other two CHPs in this country, achieved a 19% fuel saving in comparison with separate production, due to a larger value of the electric profitability. CHP-North of the municipality of Bălți operated at an efficiency lower even than the separate production.

Indices / Power plant	Global efficiency	Electric efficiency	Fuel saved, %
CHP-1 Chişinău	*0.88*	*0.12*	*33.1*
CHP-2 Chişinău	*0.66*	*0.20*	*19.0*
CHP-North Bălți	*0.72*	*0.10*	*-1.2*

Urban localities provide favorable conditions for the use of installations of cogeneration, for high density of population and presence of industrial enterprises leads to a higher concentration of thermal energy consumption. (*Box 4.5*).

Box 4.5. *The potential for using installations of cogeneration in the Republic of Moldova*

By 2010 heat consumption in urban, in the residential and public sector localities will raise up to 25 PJ, and in the industrial one up to 10 PJ [8]. Assuming that the share of cogeneration in heat production is 60% and the coefficient of installed thermal capacity use is 0.5, the perspective thermal power of installation of cogeneration in the Republic of Moldova was estimated as 1300 MW. If we subtract from this amount the efficiently usable capacity at CHP-2 Chişinău some 300 MW, we obtain the potential value of installations of cogeneration, to be put into service during the period of 2003-2010, of about 1,000 MW. Under an average thermofication index of 0.6, the installed electric capacity will be of 600 MW. Under the coefficient of installed electric power use of 0.75, the annual energy production will be of 5.5 TWh, that is, 97% of the forecast local demand in 2010, as per the MAED study [9], or 66% of the consumption, foreseen in the Energy Strategy of the Republic of Moldova [10].

III. Heating pumps

In highly industrialized countries heating pumps are expected to have a wide perspective. According to the forecasts made by the World Energy Council, by 2020 they will account for 75% of heat production in those countries [11].

Table 4.7. *Comparative economic features of various sources of heat generation*

Heat source	Economic indices	Efficiency	Specific fuel consumption, kg.c.e./GJ
CHP	Electric efficiency	*30%*	*19.0*
	Total efficiency	*60%*	
Autonomous TP	Total efficiency	*90%*	*35.9*
Heating pump	Coefficient of performance	*3.5*	*27.1*

By their main indicator - specific fuel consumption, - heating pumps have certain advantages over high efficiency autonomous TPs, but can't compete with installations of cogeneration (not even with the ones of medium efficiency). Despite all these, if they prove to be economic competitive with traditional thermal sources, heating pumps are efficiently used. For example, in Gothenburg (South Africa), heating pumps with a total thermal capacity of 165 MW are operating with average transformation coefficient of 3.5, producing annually 2.16 PJ. However, it is believed that in the Republic of Moldova by 2010 heating pumps will be reasonably used only by remote consumers, situated far from centralized systems, due to the high cost of the equipment (up to 7,000 USD/kW [11]).

IV. Fuel substitution and use of renewable energy sources

Biomass and communal wastes. It is advisable that in rural localities and suburbs fossil fuel be substituted by biomass (forest and agricultural residuals, municipal and industrial wastes), which can be used both in stoves and individual boilers, as well as in small and medium thermal plants. For that it is appropriate to use agricultural residuals: flower-sun and corn stalks, brushwood and wood from pruning vineyards, orchards, and forests, as well as from special lignin plantations [12]. To facilitate the burning, plants and woods can be chopped, and for storage and transportation – they can be briquetted.

In 1999 in the Republic of Moldova there were 3,256.9 thousand tons of agricultural wastes [13], equaling 1,768 thousands t.c.e., out of which flower-sun and corn stalks constituted 1,470 thousands t.c.e.

According to the same sources, there were 1,450 thousand tons of natural fuel (t.n.f.), or 787 thousands t.c.e. of wooden wastes.

The "2000 year Energy Balance of the Republic of Moldova" stipulates a wooden waste consumption of 24 thousands t.c.e. [14]. 77 thousands t.c.e. of wood should be added hereto. As a result, the biomass included the country's energy balance represents 4.5% of the total quantity of energy resources.

As shown in the "Energy Consumption in the Republic of Moldova. Informative Bulletin, 1997.

A publication made within the designed TACIS EMO 94001" in 1995 the biomass consumption of 360 thousands t.c.e. amounted to about 6% of the total quantity of primary energy resources, proving thus the existence of large reserves for fossil fuel substitution [15]. Lignin plantations or plantations of forest cultures for energy purposes (native and Euro-American poplar species, red oak, willow, pseudo-acacia, etc.) are another possible source of biomass.

In urban localities municipal wastes represent an important reserve of fossil fuel substitution. According to "The National Strategy for Sustainable Development. Moldova XXI", at present the annual production of municipal wastes is of about 300 kg/inhabitant/year [8]. In such localities wastes generation is concentrated and its collection is organized. If we admit that in 2010 the wastes production per capita will be at the present level, the country's urban population of 1,656 thousands will produce some 500 thousands tons per year. If recyclable materials (paper, plastic, metals, glass) will have a share of 25%, after recycling there still will remain 350-400 thousands tons per year of wastes. Those amounts of wastes could be burnt in hot water boilers of TPs and CHPs, both separately and in combination with fossil and non-fossil fuel. The burning heat of municipal wastes (after their sorting) is quite low, of only 3.5 GJ/t, so the annual quantity of such wastes collected in urban localities equals 45-50 thousands t.c.e. The biogas resulting from anaerobic fermentation of organic substances represents a specific type of non-fossil fuel. Animal manure and sewage sludges are substances most frequently used for this purpose. Biogas production from these substances has a double ecological effect due to the abatement of GHG emissions resulting from fossil fuel substitution and recovery of emissions of methane, ammonia and other gases - produced during anaerobic decomposition animal evacuations.

Solar energy. The Republic of Moldova has huge reserves of solar energy. The total annual radiation under real atmospheric conditions is of 4-5 GJ/m2. The annual energy demand of our country could be met mainly by collecting solar energy. Though this calls for huge investments, which could be recouped in 10 to 15 years. It is reasonable to use solar energy both in rural and urban localities to heat water during the hot period of the year (April - October). By the cost of thermal energy the helio-thermal installations are competitive with autonomous thermal plants, but cannot compete with installations of cogeneration.

Geothermal energy. In the Southern part of our country there are resources of geothermal energy with a temperature of 40-100 ^{o}C, which can be used in greenhouses, balneotherapy, in the systems of water supply and heating for households in the near localities, but there are no data to be used to compute the feasibility of such resources.

4.2.2. Rehabilitation of thermal networks and of thermal energy use installations

Network re-equipment can be carried out as follows:

- By using pipes pre-insulated with polyurethane expanded in polyethylene casings installed directly in the soil, without any concrete tubes and with the minimal number of chimneys for visits;
- By replacing, at the thermal points, of the tubular heat exchangers with the ones with plates;
- By liquidation of certain thermal points by transferring of the respective equipment within the buildings;
- By equipping central thermal points with high performance heat meters.

The consumption of heat can be significantly reduced if energy is conserved directly at beneficiaries. Besides measures implemented in constructions, such as: thermal rehabilitation of buildings, enhancement of spatial and building solutions of buildings, passive usage of solar energy, buildings' heating systems and installations of thermal energy usage should be re-equipped as well.

This could be done by actions as follows:

- equipment of heating installations with thermostat-faucets to individually regulate the thermal regime in each room;
- using modern heating installations (steel or aluminum panel with wings);
- using heating systems with low potential (45/30 ^{0}C) through floor or ceiling, using plastic pipes;

– equipping heating installations with automated systems of functioning regime regulation in accordance with climatic parameters variations (temperature, solar radiation intensity, wind speed) within the exterior environment.

An important positive effect could be obtained if meters are installed on the consumers side, and namely to install heat meters at each apartments block and hot water meters in each apartment.

Such measures have been successfully implemented in a number of EU countries: in Denmark and France the energy consumed to heat 1 m^2 decreased by 45% [16,17], and in certain types of blocks - up to 75%. If losses in the thermal power sector are diminished by 20% only, by 2010 the fuel consumption in urban payments and public sectors will go down by about 200 thousands t.c.e. and GHG emissions - by about 400 thousands tons.

4.2.3. Enhancement and Rationalization of Thermal Energy Supply Systems

The efficiency of thermal energy supply systems can be enhanced both via restructuring, demonopolization, privatization, management improvement, as well as via certain technical measures, and namely:

– placing heat sources in the geographical centers of heat consumption;
– using in large centralized heating systems a number of heat sources, uniformly placed and linked through circular networks;
– regulating thermal charges in terms of quantity;
– enhancing the parameters of thermal bearers.

An optimal placement of sources and the use of a number of sources within a single system will lead to diminution in pipe diameters, energy consumed during the transportation of thermal bearer, losses of thermal bearer and heat in networks. Thus, if the network length is reduced from 5 km to 1 km and pipe diameter is reduced from 500 mm to 250 mm, the energy consumed during the transportation of thermal bearer will decrease twice, and heat losses - 5 times. In addition, these measures augment the system viability and the safety of sustainable and quality supply to consumers.

Quantitative adjustment through ordinary thermal carrier intensity, according to thermal charge curve and exterior temperature using high capacity buffer-reservoirs, if compared to the qualitative adjustment through the temperature of thermal bearer, used by us, has a number of advantages, such as:

– it allows to decrease the installed thermal power of the equipment, by replacing it with the tank's capacity;
– diminishes the cost of energy for the transportation of thermal bearer;
– assures uniform functioning, under normal regime with high performances of TPs' boilers;
– allows CHPs to function according to the electrical load curve, raising in such a way its average annual productivity.

4.2.4. The potential to reduce GHG emissions as a result of rehabilitation made in the thermal power sector

The potential to reduce the consumption of fossil fuel and emissions of GHG through the rehabilitation made in the thermal power sector was assessed for the period of 2000-2010. By 2010 the demand for heat in rural localities, that equals 6.5 PJ, will be added to the demand in urban and industrial sectors, resulting in a total output of some 41.5 PJ. Further, we present the distribution of the value of total output among various sources of thermal energy generation as per the above data with respect to planned re-equipment, respective fossil fuel saved and reduction in GHG emissions (*Table 4.8*)

Investments have been computed on the basis of average specific costs of the respective equipment; the share of investments made in thermal power sector is assessed on the basis of the ratio of CHP revenues from the sale of electric energy to revenues from sale of thermal energy:

– Boilers on fossil fuels - 70 USD per 1 thermal kW;
– Boilers on local fuels - 100 USD per 1 thermal kW;
– CHP equipment - 750 USD per 1 electric kW, including 85 USD per 1 thermal kW;
– Helio-thermal equipment - 140 USD per 1 m^2 of solar collectors;
– Heating pumps – 1,000 USD per 1 thermal kW.

Table 4.8. *Economic and environmental peculiarities of the rehabilitation made in the thermal power sector*

Thermal energy production sources		Energy production, PJ	Investments, mil. USD	Heat savings, %	Fossil fuel savings, thousands t.c.e.	Reduction in GHG emissions, Gg
Thermal plants (TPs)		13.5	–	–	–	–
New thermal plants	fossils	9.0	67	15	46.1	92.2
	local*	4.0	95	100	136.5	273.0
Solar energy		3.0	675	100	102.4	204.8
Installations of cogeneration		21.0	–	–	–	–
Newly established installations of cogeneration		16.0	750/80**	47	256.7	513.3
Heating pumps		0.4	18	25	3.4	6.8
Total		41.5	1,305	–	545.1	1,090.1

It is possible to save fuel over 500 thousands t.c.e. per year, that is, 9% of country's total consumption of energy, or some 50-60 mil. USD annually saved for the purchase of energy and energy resources (according to data of the Moldovan Ministry of Economy).

If all planned actions of rehabilitation in the thermal power sector are implemented, GHG emissions will be abated by about 1.1 mil. tons.

4.3. Transportation sector

In a developing economy, where the economic decline hasn't been stopped yet, there is a considerable uncertainty in assessing the potential of abating emissions of GHG in the transportation sector through implementation of high-tech in this sector.

At present, increase in energy efficiency and decrease in fuel consumption represents the most real possibility to diminish GHG emissions resulting from the transportation sector [18, 19, 20]. This can be carried out as follows:

- By gradual reduction in of life period - from 7 to 4-5 years - for automobiles since their import;
- Granting preferential credit for the purchasing economic means of transport (having a high efficiency and low fuel consumption);
- Using more widely railways and river transport;
- Electrification of the railways and reconstruction of Răvaca - Căinari railway segment. It will decrease twice the portion of the line, in comparison to the existing one Răvaca - Tighina - Căuşeni - Căinari, and, consequently, the fuel consumption will decrease twice, as well;
- Pushing the transit transport out of cities;
- Transport networks optimization, keeping relatively constant circulation speed;
- Developing public transport networks, including the electric ones (trams and trolleys);
- Optimization parking lots in large cities;
- Encouraging imports of high quality fuel.

As per certain assessments, the following main measures could lead to a reduction in emissions of GHG by 10-15% of the current emissions registered in the transport sector (110 - 170 Gg):

- Renew the fleet of rolling stock so as to use transportation units with economical fuel consumption;
- Repair, modernize and maintain in good service the network of roads;
- Electrify railway portion of line Razdelnaia - Ungheni;
- Reconstruct railway sector Răvaca – Căinari;
- Build a highway belt around the municipality of Chişinău;
- Develop electrified networks of public transport in urban localities.

These measures call for huge investments, therefore they could be implemented over the next 5 to 7 years.

Other measures, less expensive, could contribute to a reduction in GHG emissions by about 3-4% of the current emissions in the transport sector (some 35-45 Gg). It is meant the following:

- Increasing the amount of goods transported via railway or rivers;

- Establishing the so-called “green light” for the communication ways where the traffic is controlled by traffic lights;
- Applying certain economic measures and tax policies to encourage the renewal of the fleet of rolling stock;
- Enhancing vehicle parking in cities and facilitate the use of public transport.

However, considering the technical state of the fleet of rolling stock and the fact that it will be renewed gradually, the quality of communication ways being the same or rather continuously degrade, we could expect a slow escalation in fuel consumption as, consequently, of GHG emissions. If the economic situation is improved, this enhancement could be greater, especially in the case of unintegrated approach to environmental and sustainable development issues.

4.4. Renewable Energy Sources

4.4.1. Wind energy

The potential to abate GHG emissions through the use of wind installations. “Draft frame program of the Republic of Moldova on renewable energy sources (RES) implementation” stipulates that by 2010 2% of the total consumption of primary energy, that is about 130 thousand t.c.e. per year, being generated by wind. We believe that, for an optimal specific consumption feature of up-to-date CHPs worth 0.35 kg.c.e./kWh, 370 mil. kWh/year of electric energy correspond to the this amount of fuel.

The volume of polluting gases emissions (CO_2, SO_2, NO_x), resulting from electric energy production at thermo-electric plants depends on the type of fuel and technology used, installation efficiency and means of environment protection (*Table 4.9*).

Table 4.9. *CO_2 emission when using different technologies of electric energy production*

Technology	CO_2 emissions (g /kWh)
Coal combustion	*954*
AEBC	*963*
IGCE	*751*
Residual fuel oil combustion	*726*
Natural gas combustion	*484*

All domestic power plants, and the ones in Ukraine and Russia, which Moldova imports electricity from, are mainly operating on natural gases and oil products and a using coal to a less extent.

In order to assess the potential to abate GHG emissions through the use of wind energy there were used the following emission coefficients [21]: 710 g CO_2/kWh; 2.9 g SO_2/kWh, and 2.6 g NO_x/kWh. If we use wind energy and generate 370 mil. kWh / year of electricity, we will tremendously abate the emissions of polluting gases (CO_2 – 262,700 t/year, SO_2 – 1,073 t/year, NO_x - 962 t/year).

Replacing a part of the electric energy produced at power plants with the energy produced at wind plants, a considerable environmental benefit will be achieved, avoiding the emission of over 260 thousand tons of CO_2 and some 2 thousand tons of SO_2 and NO_x, which have a severe negative impact on the population’s health. At the same time, acid rains containing these elements causes the degradation of forests and agricultural produce. The damages produced by SO_2 and NO_x emissions are estimated at 6,000 Euro/year [18]. Consequently, there will be a 12 mil. Euro/year extra benefit as a result of avoiding the above-mentioned emissions. The respective decrease in electricity import will increase the state energy security.

The use of wind plants will lead to a reduction in the quantity of other polluting wastes (dust, slag, etc.) with a negative impact on flora and fauna. At the same time it will create new places of work in rural localities.

In order to implement the Frame Program with respect to electric energy production at wind plants, amounting to 370 mil. kWh/year (by 2010), it will be necessary to build wind plants with a total installed capacity of about 120 MW. It was considered that air-generators with 0.6 - 2 MW nominal power with the height of the tower of 70-90 m will be used, in order to guarantee, under the local meteorological conditions, the most favorable location on the territory of the republic (utilization coefficient of installed power – k_u = 0.35).

As per computations [21], done through the general methodology used for such energy objectives [22], specific capital investments equal 1,000 – 1,250 USD/kW, including the cost of air-generators, construction of civil and electric infrastructures, expenses for transportation, setting-up, and putting into operation. (*Table 4.10*)

Table 4.10. *Technico-economic indices regarding the use of wind energy*

Installed capacities, thousands kW	*120*
Energy produces, mil. kWh/year	*370*
Investments per unit of installed capacity, USD/kW	*1,000 - 1,250*
Total investments, mil. USD	*120 - 150*
Potential of GHG abatement, thousand tons/year	*264*
Cost of GHG reduction measures, USD/ton	*22.0 - 27.5*

These computations were done taking into account the adjustment and operating terms of the main equipment of some 20 years.

4.4.2. Solar energy

The potential to abate GHG emissions through the use of solar installations. The potential to abate GHG emissions and replace fossil fuel through the use of solar installations is assessed for:

– water heating in the rural sector;
– fruits, vegetables, and herbs drying;
– water pumping for small irrigation;
– electricity supply to anti-hail stations.

The methods to assess the energy demand for the above areas, the technical and economic indices of different installations are described in the study "Non-polluting energies. Technological, economic, environmental and energy security aspects" [22]. The National Strategy for Sustainable Development [13] stipulates for 2010 a 10% share of RES in the total energy consumption, that it, 650,000 t.c.e. It includes the energy obtained at hydro-electric plants, from winds, biomass, and solar energy (2.3% of the total energy consumption or about 150 thousand tons a year). At the same time, replacing a part of the thermal and electric energy produced by solar installations for water heating, fruits, vegetables and herbs drying, PV installations for water pumping and electric energy supply to anti-hail stations, the quantities were assessed of CO_2 emissions avoided on yearly basis as a result of using the solar energy (about 317 thousand tons). Taking into account the additional economic benefit, attained by avoiding damages to the environment and public health, both external expenses (costs of human activity, which are not quoted in the market system; for instance, radioactive particles emissions at a nuclear plant is affecting the health of inhabitants of the neighbor locality, but there is no market for such impacts), and the cost of using the traditional energy sources will be avoided.

a) Using solar energy for water heating in the rural sector

The demand for thermal energy for water heating in the rural sector was determined according to the study "Non-polluting energies. Technological, economic, environmental and energy security aspects" [22]. The residential sector has the greatest share - 85.6% - among all considered categories. Within this study it was used a substitution rate of the demand for thermal energy for water heating with solar energy of 50%. Taking into account the structure of fuel consumption in the rural sector, the following estimative utilization quotas of fuel used for water heating were used: 15% - for natural gas, 50% - LPG, 25% - coal, 5% - Diesel oil, 5% - electricity, 20 - wood and wood residuals. As wood does not cause an increase in GHG emissions, it wasn't considered during the computations. The quantities of fossil fuel substituted with solar energy, both in natural units and units of coal equivalent, as well as the abatement in GHG emission, was computed on the basis of the specific demand for thermal energy [22], data about the efficiency of installations, specific GHG emissions and fuel caloric value (*Table 4.11*).

Table 4.11. *Quantities of substituted fossil fuel and GHG reductions resulting from the use of solar installations for water heating in the residential sector*

Substituted fuel	Thermal energy, thous. GJ	Natural units	Coal equivalent, thousands t.c.e.	GHG reduction, thous. t
Natural gas	*503*	*15 mil. m³*	*18.3*	*29.7*
Liquefied gas	*1,338*	*26.8 thous. t*	*44.8*	*85.6*
Coal	*1,029*	*46.8 thous. t*	*36.4*	*102.9*
Residual fuel oil	*179*	*4.4 thous. t*	*6.3*	*14.0*
Electricity	*425*	*425 thous. GJ*	*14.6*	*10.4*
Total	**3,474**	–	**120.4**	**242.6**

In order to achieve these GHG reductions, it is necessary to install about 1.6 mil. m^2 solar collectors by 2010. Thus, a family of the rural sector [22] will need an autonomous solar installation with a collector of about 3.8 m^2.

b) Solar installations for fruits, vegetables, and herbs drying.

At present about 1,500 t of fruits and vegetables are dried annually, which represents only 0.8% of fresh fruits and vegetables. The real potential is ten times higher, of about 15 thousand tons of dried products. As a proof may serve the fact that in 1991 over 10 thousands fruits were dried (1993 Statistical Yearbook). As the price for fuel has risen, production in this sector was cut. Diesel oil is used for drying, and the electric energy is used to assure air circulation. About 50% of the necessary thermal energy can be substituted with energy. In such a case, there is a potential to abate GHG emissions by 9,150 t/year, and the potential to substitute the Diesel oil can be as much as 2,900 tons (4,140 t.c.e.). The total area of solar collectors is about 80,000 m^2.

c) Pumping installations for small irrigation

Via the Government's Resolution No. 256 dated 17.04.2001 "On the repair of irrigation systems for the period of 2001 - 2008". The small irrigation has a total capacity of 36 thousands ha or 22% of the total irrigable territory of 160 thousands ha. The 3,000 reservoirs, lakes, etc, out of which 411 are the most important, will be used as water resources. It was admitted that PV solar energy be used to irrigate 35% of the territory stipulated in the Program, with a total manometric height of 40 m. The computations were done in comparison with the supply of pumping installations from a power network or from an electrogenic group on Diesel oil (*Table 4.12*).

The difference between these two alternatives (about 4 times), is due to the higher efficiency of energy conversion in the case of supply from the network. At the same time, the electrical network is expended over a distance of 1 –2 km., the cost is 2-4 times higher than of an electrogenic group [22].

d) Installations for electricity supply to anti-hail stations

At an anti-hail station they substitute liquid fuels (Diesel oil or gasoline) needed for the transportation of storage batteries to charge stations and the electric energy used to recharge them. In addition, the quantity of noxious wastes will diminish by 5.6 t/year as a result of storage batteries repair. The computations were done for the existing 150 stations. It is considered that a season runs from April to September.

Table 4.13. *The quantity of substituted energy and fuel and GHG abatement as a result of using PV installations for anti-hail station electricity supply*

Energy or fuel	Natural units	t.c.e.	GHG reduction, tons
Electricity	*9.88 thous. kWh*	*3.2*	*7.6*
Diesel oil	*9.0 t*	*13.0*	*28.4*
Total	–	**16.2**	**36.0**

The costs of measures aimed at abating GHG emissions have been computed for the above-mentioned 4 solar installations. The study period for all types of solar installations is 20 years. The cost of measures have been determined as the ratio of annual investments to the annual quantity of GHG emissions expressed in tons (*Table 4.14*)

Table 4.12. *The share of fossil fuel substituted and GHG reduction resulting from utilization of solar PV installations for water pumping*

Alternatives of electric energy supply	The irrigated area, thousands ha	Substituted energy or fuel		GHG reductions, thousand tons
		natural units	thousands t.c.e.	
Public network	*12.6*	*7600 MWh*	*2.483*	*5.733*
Electrogenic group	*12.6*	*7.56 thousands t*	*10.8*	*23.8*

Table 4.14. *Total investments and the cost of measures aimed at GHG diminution for different solar installations*

Indicatori / Solar installations:	Water heating	Agricultural produce drying	Small irrigation	Anti-hail stations
Total area of solar collectors or PV modules, m^2	*1.6 mil.*	*80 thous.*	*85 mii*	*55*
Investments per unit	*143 US$/m²*	*60 US$/m²*	*3,043 US$/ha*	*228 US$/station*
Total investments, mil. USD	*228.8*	*4.8*	*38.3*	*0.034*
Potential to diminish GHG emissions	*242.6 thous t*	*9.16 thous. t*	*23.8 thous t*	*36 t*
The cost of measures aimed at diminishing GHG emissions, USD/t	*49*	*26*	*8*	*47*

The highest costs of measures aimed at abating GHG emissions are incurred at PV solar installations used for small irrigation, a fact explained through significant investments in photovoltaic installations. Respectively, the lowest costs are incurred by solar installations for fruits and vegetables drying. At the same time, it should be mentioned that the implementation of these two types of solar installations brings the highest social and economic benefits: new jobs are created in the rural sector; export possibilities raise; the processing industry is assured with raw material; food and state security strengthens; the dependence of agricultural produce on climatic factors decreases.

4.4.3. Biogas energy

The potential to abate GHG emissions through the use of biogas installations. The total volume of the biogas recoverable from different sources of biomass consists of:

- Animal manure – 19,116 thousands m^3/year;
- Sludge from communal wastewater treatment plants– 22,000 thousands m^3/year;
- Industrial wastewater treatment plants – 14,705 thousands m^3/year.

The following amounts can be recouped among MSW:

- From equipped landfills – 3,125 thousands m^3/year;
- Through “Valorga” wet process – 69,300 thousands m^3/year.

About 125 thousands m^3 of biogas, estimated at 62.5 thousand t.c.e., can be annually recovered through anaerobic fermentation of organic wastes (the available capacity). In other words, this equivalent will conserve annually energy obtained from fossil fuel and, respectively, methane emissions will decrease by about 75 thousands t/year, representing about 1,575 thousands t CO_2 emissions equivalent.

The cost of measures aimed at abating GHG emissions through the use of biogas installations. The technico-economic indices of biogas installations for sludge and liquid animal evacuations fermentation are presented in Table 4.15 and annex 4.1, being computed in accordance with data on fermentation with capacities of 250 – 1,500 m^3 offered by S.C. IPROMED JSC Bucharest (the exchange rate of MDL was 12.87 for 1 USD).

The absolute economic efficiency of capital investments is determined through the ratio of the annual economic effect less operating and maintenance expenses to the capital investments, which assures this effect. The above alternatives have been computed taking into account the inflation and accepting a 15% inflation rate and 20% actuate rate. In order to compare the alternatives for capacities of 250, 750, and 1,500 m^3 the discounted total costs (DTC) and net present value were computed.

On the basis of the above-mentioned we can conclude that:

- Anaerobic filtration installations producing biogas with a capacity of 1,500 m^3 can yield revenues worth 830.98 thousands MDL in the Republic of Moldova, and capital investments for its constructions can be paid off in 1.5 years;
- Anaerobic filtration installations producing biogas with a capacity of 750 m^3 can yield revenues worth 415.49 thousand MDL, and capital investments for its constructions can be paid off in 6 years;
- Anaerobic filtration installations producing biogas with a capacity of 250 m^3 can yield revenues worth 132.55 thousands MDL in the Republic of Moldova, and capital investments for its constructions can be paid off in 11 years;
- As the design and construction of biogas installations call for huge capital investments (the production cost of 1 m^3 of biogas ranges between 0.61 and 1.48 USD/m^3, and at optimal operating indices and under the condition of selling the fermented sludge as manure, the capital investments (without considering the inflation rate) for the use of anaerobic fermentators with capacities of 250, 750, and 1,500 m^3 could be recouped in 50, 13, and 6 years respectively), at present such investments can’t be made in the Republic of Moldova, as they will be borne with difficulties both by farmers and the housing sector;
- Environment protection should be a must during liquid wastes stabilization or fermentation, so that biogas installations could operate efficiently in a long run, even if the state gets actively involved, with a share of at least 50% in the overall investments.

Table 4.15. *Technico-economic indices of biogas installations*

Technico-economic indices	Unit of measure	Installed capacity, m³		
		250	750	1,500
		Useful capacity, m³		
		200	600	1,200
Total investment	thous. MDL thous. US$	*1,494.21* *116.10*	*2,353.15* *182.84*	*3,171.17* *246.40*
Gross biogas production	thous m/year³	*91.00*	*273.00*	*546.00*
Net biogas production	thous m/year³	*71.00*	*215.00*	*430.00*
Total biogas production heat equivalent	Gcal	*373*	*1183*	*2366*
Cost of net biogas production, heat equivalent (325.86 MDL / Gcal)	thous. MDL thous. US$	*121.55* *9.44*	*385.49* *29.95*	*770.98* *59.90*
NPK type fertilizers production	tons/year	*5.05*	*15.0*	*30.0*
The cost of NPK type fertilizers production	thous. MDL/year thous. US$/year	*11.0* *0.85*	*30.0* *2.33*	*60.0* *4.66*
Total revenues	thous. MDL/year thous. US$/year	*132.55* *10.25*	*415.49* *32.28*	*830.98* *64.56*

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5. POLICIES AND STRATEGIES
THE ENERGY SECTOR AND THE ENVIRONMENT

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The fundamental problem of the XXI century, stated in June 1992 at the World Conference for Environment and Development that took place in Rio de Janeiro, Brazil (The World Summit) is made up by the maintenance of a long-term environment. The symbiosis relation between the development and the environment was amply considered in the report, remitted to the general secretariat of the United Nations by the World Commission on Environment and Development, emphasizing the idea that the economical development can not be long-term or guaranteed, without the environment protection.

Because of the especially serious GHG emissions impact on the planet, most of the countries of the world make supported efforts to stop the clime disaster that could affect the entire Earth. As the main source of the GHG emissions is the energy sector, at present, new solutions are being looked for to satisfy the energy necessities and new tackling of the social-economic development strategies with a view to assuring a long-term and prosperous development.

5.1. Policies and Strategies in the European Union

I. The energy sector

The long-term development of the society and the environment concerns are two major objectives of the European Community – stipulated in the European Union Treaty (2 and 6 Art. [1]). Several years ago, the European Council decided that the responsibility and the control of these two priorities must be delegated from the environment authorities to those of sector policy (Cardiff, 1998). Because the energy sector exercises the highest influence on the environment, the major environmental and sustainable preoccupations became part of the European Community policy.

Recently, the European Commission presented its strategic objectives for the period until 2005, mentioning that the power sector is the key-factor for the economical community development and for making it efficient. Nowadays, in the European Union (EU), they speak more and more often about *an integration of the environmental and long-term development aspects in an energy policy for a long period.* In this context, the European energy sector is seen as a "multifunctional" branch that would satisfy the following imperatives:

- to assure a continuous supply – without interruptions and limitations, with energy resources;
- to be competitive and efficient;
- to assure the economical increase, setting up new working places for the welfare of the population;
- to contribute to the environment protection.

This vision, starting from 1996, was developed through a series of the EU energy policy documents [2-8].

The European strategy concerning the security of supply

As a result of the implementation of the major provisions of the EC White Paper concerning the energy policy of the EU [2], in the past five years, in the West Europe, a number of radical changes, with a view to the liberalization of the electricity and fuel gases markets in all the EU Members States and their future on integration, forming two common markets: of electricity and of the gases. In this way, in the EU Member States the legislative frame, the organizing the industry structure and the way of the energy market operation had been substantially modified. It is to mention that, as a consequence of the liberalization of the energy markets, the frame in which the energy security is assured also is considerably transformed.

Besides this spectacular evolution, during many years, in the energy sector two factors that brings about a deeper and deeper preoccupation at the national and European level, persist: the continuous increase of the energy dependence of the EU and the climate change phenomenon.

Being preoccupied by the proportions of the climate change phenomenon, the European Union intends to respond by implementing the provisions of the Kyoto Protocol [6]. The energy policy plays a key role in respecting the engagements specified in this document.

Regarding the energy dependence of the European Union by the energy resources import [1-4], it is to mention that, at present, the EU Member States import about 50% of the consumed energy. In case of a similar evolution, to 2020-2030 the import may reach 70%, 80% and, 90% respectively for gases, coal and oil. Such a situation may have serious economical consequences – a fact proved by the trebling of the raw petroleum price in 2000.

The availability of the regional and world energy resources is not critic. But the problem consists in the paid for the imports price, on one side, and in the economical and political risks caused by these imports, on the other side.

In this way, the European Commission decided to reconsider the fundamentals of the European Union supply with energy resources, initiating an ample debate with a view to the elaboration of a strategy on addressing the external energy dependence [8]. The past years evolutions stressed the necessity to look for new solutions that would assure the reliable EU's energy supply. On the 29th of October 2000, The European Commission initiated an ample debate having as a subject the assurance of the EU Member States energy supply (EU-15) and the eventuality of an EU extension (EU-30) – to 2030.

This subject of a special importance represents the quintessence of a new European energy policy document, developed by the European Commission and named *the Green Paper – Towards a European strategy for the security of energy supply* [8].

The notion of *energy security* refers to the State's capacity to supply energy resources to the country, stabile, for a short-, middle- and long-term, with a minimal impact on the environment and by non-affecting the living standards of the population [9].

At the elaboration of the Green Paper had been taken into consideration:

– The energy situation at a regional and world scale.
– Eventual extension of the EU from 15 to 30 States.
– Possible evolution of the energy consumption.
– Future liberalization and the integration of the energy market.
– Environmental concerns.
– Possibilities of diversifying the import.

***An energy security strategy** imposes not only the increase of the power supply autonomy as, particularly, the diminution of the risks of the external energy dependence.*

***The strategic objectives of the energy security** usually deal with the consume balancing, on substitutable energy resource, and diversifying the import sources in terms of products, geographical regions, ways of transportation.*

Looking for long-term solutions for the EU energy security, the European Commission initiated public debates, launching 13 fundamental questions (*Box 5.1*). As a result of these debates that had been ended in November 2001, a strategy for the security, presented as a White Paper, must be elaborated.

Box 5.1. *The main subjects for public debates concerning the EU security of the energy supply*

1. What should the EU strategy be in the conditions of the increasing external energy dependence?
2. What policy must be adopted in the EU for the liberalization of the energy market?
3. What roles do the fiscal system and the State support have to play?
4. What kind of relations should be maintained with the countries-producers of energy resources?
5. What kind of policy should be adopted concerning the energy stocks?
6. How could be strengthen the energy supply networks?
7. What support must be given to the implementation of the renewable energy sources? Must the traditional energy sources be utilized for these supporting activities?
8. How could the EU participate in finding a solution to the wastes, nuclear security fortification and the development of the analysis concerning the future reactor problems?
9. How should EU combat the climate change phenomenon? What role does the energy economy have?
10. Is it necessary to adopt a communion policy in the sector of the bio-fuels? What would its essence be?
11. Is it necessary to utilize incentives or special regulations for the energy economy in the buildings?
12. What would be the way to encourage the substitution of the fuels for stimulating the energy and transport economies? What steps must be taken for the passing of the goods that are transported by automobiles to the railway, and to reduce the automobiles circulation in the cities?
13. How could EU, the member States, the regions, the producers and the consumers contribute to the development of a long-term system of energy supply? What should the energy options of the future be?

The integration of the energy market of the European Union Member States

In the promoting the competition on the energy market policy, on the 19th of December 1996, the European Parliament and the Council adopted the 96/92/CE Directive (the Electricity Directive) [10], and on the 22nd of June 1998 – the 98/30/EC Directive – (the Gas Directive) [11].

The principles of the European energy market liberalization, initiated in the White Paper concerning the Energy Policy of the EU [2] and subsequently materialized in the two directives, are the following [10,11]:

– The generation (production) and the supply (commercialization) of the energy, as well as the adjacent services to the consumers are competition activities that must be liberalized.

– The energy transport and distribution usually represents a national or serving region monopoly; these activities will remain regulated by the State.
– The non-discriminative access to the market of the new producers and suppliers.
– The free access (regulated or negotiated) to the transport networks for all the accredited agents.
– Buying the energy from the producers, based on the economical deserve regime.
– Regulated tariffs for transport and distribution activities.
– The consumers will gradually get the right to choose their suppliers.

It is supposed that, with the competition development and integration of the European market, the energy price will gradually decrease. The competition pressure will determine the development of producing and using the energy efficient technologies, less harmful for the environment.

The common electricity market

Recently, all the EU Member States adopted national legal deeds with a view to implementing the provisions of the Electricity Directive. The fact that many countries managed to liberalize the market much above the previously settled figures is remarkable.

The average level of liberalization make up at present about 65% of the volume of the electricity consume in the EU (*Figure 5.1*).

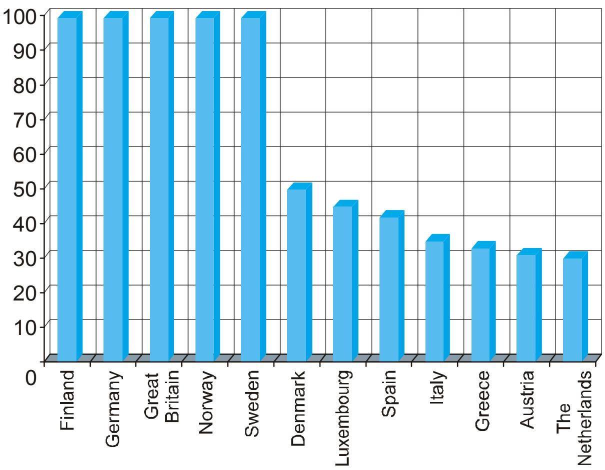

Figure 5.1. *The liberalization of the EU electricity market, % (May, 2000)*

It is to note that the Directive offered the possibility to choose between the alternative mechanisms, most of the countries making their opinions for the most reasonable market solutions, as:

– the regulated access of the third party,
– entering the market with new generating capacities through the authorization procedure,
– the total separation of the transport activity from the production/supply ones,
– setting up the independent regulating authorities.

These mechanisms are the most appropriate for avoiding the discrimination of those who are new in the market. As a result, one of the most significant obtained results - namely *the decrease of the electricity prices* – became a reality. The statistics concerning the evolution of the electricity prices in the period 1996-1999 shows that in the EU the prices decreased with 6%, and in some countries – to 20%. So, all the electricity consumers – the private individuals, the small enterprises and the industrial sector – have to gain from this prices decrease.

It is to mention that EU is the most advanced zone in the world in transforming the national separate energy sectors, dominated by monopolies, in an integral regional electricity market. The final objective of the EU is forming an integral total market, not a combination of 15 markets, more or less liberalized.

The common fuel gases market

Since the adoption of the Gas Directive, all the EU countries initiated the preparing activity for the realization of this document's stipulations, starting with 2000.

One of the key-elements of the common gas market is the right of the consumer to choose the supplier on the entire European territory. This right is stipulated in the Directive by offering gradually to some categories of beneficiaries the status of *eligible consumers.* It is supposed that promoting the eligible consumers, as well as the offered by the emergence of the new suppliers on the internal market opportunities will increase the pressure on all the operators to:

– improve the quality of the services;
– reduce prices;
– decrease the prices for the delivered natural gas.

The new suppliers on the market will have the right to commercialize the gases and to initiate infrastructure projects, contributing in this way to extending and diversifying the delivery capacities, as well as to the natural gas supply security.

The Directive establishes the common rules for the transport, delivery, supply and stocking of the natural gases. This rules concern the organization and operation of the natural gas sector, including the liquid ones, the access to the market, the systems operation, as well as the criteria and procedures that are applied to the licensing the market operators.

The Gas Directive is stipulating the following principles:

– The liberalization of the market (by offering the status of eligible consumers).

– The non-discriminative access to the natural gas delivery system.

– The separation of the units (enterprises) vertically integrated.

– Non-discriminative rights to the construction of some natural gas infrastructure facilities.

– Ceasing the practices of attributing exclusive rights to operate on the market.

The EU Member States must assure the necessary conditions for the gas sector enterprises could function in accordance with the principles of the Directive, in this way contributing to reaching the final aim – a competitive natural gas market for all the operators.

According to the Directive, the natural gas market will be gradually opened during an 8 years period, following the objective that its share to be of at least 33% until 2008 (*Table 5.1).*

Table 5.1. *The perspectives of the natural gas market liberalization*

Stage	Degree of opening the market, %	Accepted quantity, mil. m^3	Limit-level of opening the market, %
August 2000	*20*	*25*	*30*
August 2003	*28*	*15*	*38*
August 2008	*33*	*5*	*43*

The tempo at which most of the Member States began to implement the Directive varies from country to country. For example, in Great Britain only some minimal modifications in force legislation had been necessary to make a reality the demands of the Directive, while in France, the rigor modifications has not been operated yet, though in this country the gas market had been liberalized (*Figure 5.2*).

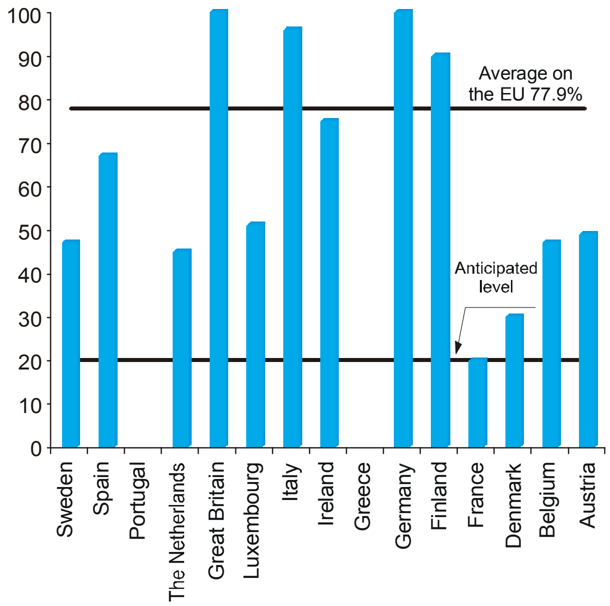

Figure 5.2. *The degree of the gas market liberalization in the EU countries (August 2000)*

The Directive supposes the progressive opening of the natural gas market, a first important step in this purpose being the right of the large consumers to choose their supplier. The European countries must make sure that on the eligible consumers list are all the power plants that utilize natural gas, regardless of their yearly consumption, as well as other consumers, with yearly settled consumption volume, higher than the *brink of eligibility*.

Strategic aspects concerning the energy efficiency

In 1998, The European Commission launched the Communication concerning the energy efficiency [13]. In this communication the commitments taken in the area of the energy efficiency at a community scale are reflected. Particularly it is stipulated:

– the evaluation of the economic potential for investments and the obstacles that hinder the investments in the energy efficiency;

– the analysis of the promoted policies;

– the identification of the relevant actions at community, national and regional levels;

– preparing a basis for the common policies and actions that proceed from the engagements of the Kyoto Protocol.

In accordance with the estimates, during 1998-2010, the economic potential of improving the energy efficiency in all the spheres made up about 18% of the total consumption volume of 1995. In this sector, there is a number of barriers (economic, energetic and institutional-legislative) that must be overcome.

The main steps concerning the increase of the energy efficiency are promoted by:

– the technological programs, as Joule-Thermie;
– the Save program, mainly focused on the elaboration and approval of the legislative documents, as labeling the energy consumption at the refrigerators;
– the support of the investments through the European Regional Developing Funds and the Cohesion Fund;
– the international co-operation – Phare, Tacis and Synergy programs.

Besides these programs, a strategy for the rational utilization of the energy is proposed in the Communication. The following fields of activity are considered to have priority for a short and middle term:

– the increase of the energy efficiency in the buildings;
– bringing up-to-date the Directive of the Council 93/76/EEC concerning the limitation of the CO_2 emissions;
– the utilization of domestic devices and other equipment with efficient energy consumption;
– extending the information degree in this sector;
– financing by way of third parties some other schemes of creative financing;
– the increase of the energy efficiency in the electricity and fuel gas sector at the power cogeneration plants;
– the energetic management, as well as buying new technologies.

In 2000 [14], the European Commission initiated a Plan of Actions for the improvement of the energy efficiency, this document making up a logic development of the Communication, elaborated by the Energy Efficiency Committee.

The initiation of the Plan of Actions comes from the necessity of revising the community and Member States commitments to promote more actively the energy efficiency, necessity that became more obvious from the viewpoint of the Kyoto engagements to reduce the GHG emissions. In this context, the energy efficiency has the main role in abating these emissions.

Besides abating the emissions, the energy efficiency will lead to a more sustainable development of the energy sector and a higher security degree in the energy resources supply. The Plan of Actions defines the policies and the steps that have the purpose of removing the obstacles from the way of promoting the energy efficiency, the increase of the use of co-generating technologies degree. The following three groups of actions are presented in the document:

– steps to integrate the energy efficiency objectives in other community policies and programs (regional and urban policies, tariff and taxation policies etc.);
– the consolidation of the existing community capacities in the area of energy efficiency increase;
– new policies and steps (encouraging the development of the new technologies, promoting the energy audits in industry and the housing sector, information concerning the new efficient technologies).

The Community Strategy for promoting the cogeneration of electric and thermal energies and removing the obstacles in developing these technologies [15] also joins the context of the energy efficiency policy. It is to mention that the energies cogeneration concept is an old one, promoted insistently as early as in the 70s of the XX-th century. In accordance with the respective strategy, the cogeneration is considered a priority step in the abating of the GHG emissions. The European Commission proposed the doubling – from 9% to 18% - of the cogeneration technologies share in the electricity production until 2010.

In 1997 the share of electricity produced at the cogeneration plants made up 11% of the total EU production in the internal market. The total installed capacity in the cogeneration plants made up 60 thousand MW. Germany, the Netherlands, Italy, Finland and Great Britain had the pre-eminence in terms of this indicator.

The cogeneration strategy proposes mechanisms to reach the following objectives:

– the increase of the CHP technologies financing quota through the Joule-Thermie, Save, Altener, Phare, Tacis, Synergy, Meda programs, as well as the structure funds;
– promoting the negotiated with the industry agreements, buying new technologies;
– the information change and the co-operation in this sector between the Member States;
– monitoring the impact of the European energy markets liberalization on the cogeneration and the centralized heating systems;

– including the external costs in the energy price;

– other financial instruments.

The implementation of the renewable energy sources

The EU policy in the sector of the renewable energy sources is based on the Communion Strategy and the Plan of Actions until 2010 [16]. The fundamental objective, indicated in the respective strategy [16], consists in doubling the produced from the renewable energy sources energy quota in the total energy consumption of the Community: to 2010 it is foreseen reaching a quota of 12%, given the 6% in 1998.

The Plan of Actions comprises also a number of regulating and fiscal steps referring to the internal electricity market; the principles of implementation of the community policies that would advantage the utilization of the renewable energy sources; stipulations that define the co-operation modalities between the Member States and also provisions destined to the investments stimulation and information in the area of the renewable energy resources.

The main instruments of supporting and monitoring the strategy in the sector of the renewable energy sources are the Altener Program and the "take-off" Campaign.

For the purpose of promoting the renewable energy sources, the European Commission instituted the Altener Program that includes a number of actions for the 1998-2003 period. This program objectives are:

- realizing and completing different community actions with a view to the development of the renewable energy sources potential;
- harmonizing the standards of the products and equipment on the renewable energy sources market;
- supporting the pilot-actions in infrastructure, which stimulates the financing of the producing the renewable energy technologies, as well as the increase of their competitiveness;
- increasing the information and coordination degree at an international, European, national and local levels;
- supporting the actions for drawing the investments in the producing renewable energy sources, as well as the increase of the generating capacities of the renewable energy sources.

Trough the "*take-off*" Campaign the acceleration of implementing the Strategy in the sector of the renewable resources is being followed. This campaign has as a main objective the forming of an integral frame for the estimation of the investment opportunities, as well as the drawing of the private and public financial sources in producing energy projects from renewable sources (*Box 5.2*).

Box 5.2. *The objectives of the "take-off" Campaign for 2003*

- 1 mil. photovoltaic systems;
- 15 mil. m^3 solar collectors;
- 10 thousand MW wind air-generating installations;
- 10 thousand MW installed capacity in the cogeneration plants utilizing biomass;
- 1 mil. houses, heated utilizing the biomass;
- 1,000 MW combusting the bio-gas installations;
- 5 mil. of liquid bio-fuels;
- 100 localities, supplied with 100% from the renewable energy sources.

To encourage and support the engagements of the implicated in the "take-off" Campaign third parts, the "*Partnership for the renewable energy sources"* has been initiated between the European Commission, on the one side, and the public authorities, industries and other participants, on the other side.

In 2001 the European Union adopted for the first time a directive that has as a purpose the promotion of electricity production from the renewable sources [17], because the respective sources quota is still quite low on the EU internal market. It is to mention that only the wind energy producing sector known a real "explosion" during the 1989-1998 period – because of the technical progress and the legislative steps.

The key-objectives of this document:

- increasing, until 2010, the electricity quota produced from the renewable sources from 14% to 22% of the internal electricity consumption;
- doubling, until 2010, the renewable energies quota (from 6% to 12%) of the EU total energy consumption;
- realizing the commitments of the European Union in the Kyoto Protocol (1997) concerning the diminution of the GHG emissions.

In the meantime, the promotion of electricity production from renewable sources will be based on the following criteria:

- establishing the national objectives concerning the electricity produced from renewable sources;
- elaborating national schemes of supporting the RES utilization technologies;
- simplifying the administrative procedures for providing the location authorization to the energy production installations;
- guaranteed access to the electric networks of transport and distribution.

In the *Figure 5.3* [18], an approximate estimation of the electricity price is given, produced through different technologies.

The EU energy policy, as well as the afferent legislation, comprises the whole specter of concerns and practical actions of the electricity production and consumption. The General Directorate for Energy system and Transports (GD ENTR) of the European Commission introduced a certain structurization of the legal-normative framework of the energy sector that facilitates considerably the reaching of the proposed objectives (*Annexes 5.1 and 5.2).*

II. Environment policies

The energy policies promoted by the European Union were and continue to be priority concerns co-related with the environment protection ones. Through many initiatives and important decisions, the EU created a strategic framework through which the Community supports the efforts for the environment protection. In 1998, at the Cardiff Summit, the European Council initiated the initiative of integrating the environment and sustainable development aspects in the energy policies. The main idea lies in delegating the responsibilities and the control from the environment authorities to the sectoral policies authorities, which plan and implement the specific actions in this sector. Because of the reminded above initiative, the way of approaching the environment-energy co-relation made a substantial progress, as:

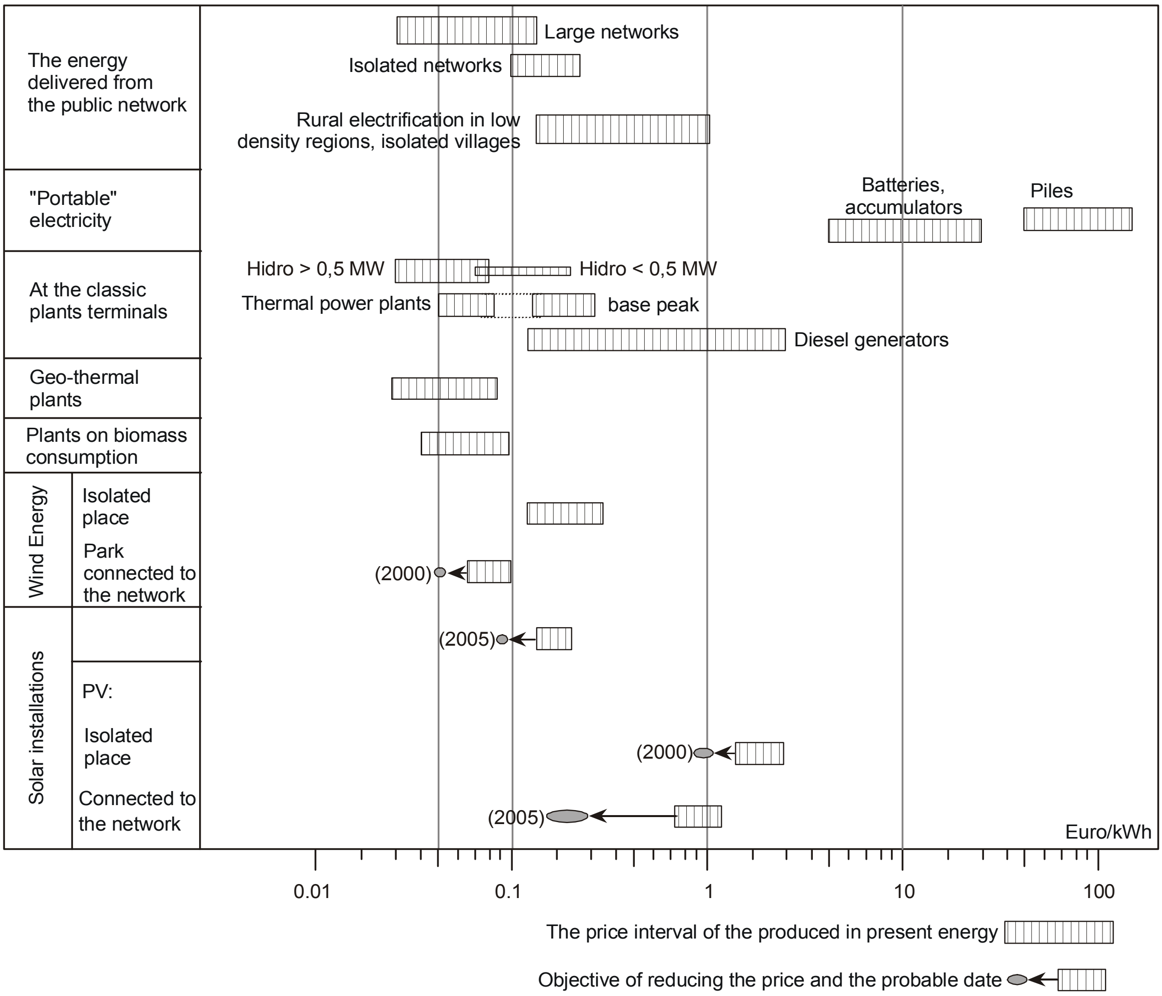

Figure 5.3. *The comparison of the electricity price obtained through different sources*

- The Energy Council adopted strategies for integrating the environmental policies;
- The European Commission responded to this initiative in the same year, presenting the Communication for the environment aspects in the community energy policies [4];
- On the basis of the Commission Communication, the European Parliament issued a resolution concerning the integration of the environment aspects in the community energy policy [5];
- At the end of 1999, the Energy Council, in its report to the European Council, presented at the Helsinki meeting (ENER 140/ENV 462), generalized the visions concerning the environment problems integration. In this report, the European Commission has been proposed to revise and to fit its energy policy each two years.
- As a result, the European Commission presented in 2001 the first report for the environment and long-term aspects integration in the energy policies. The report comprises the recent evolutions, described in the communication concerning: the preparation for implementing the Kyoto Protocol [6], which initiates the European Climate Change Program (ECCP) and the sixth Action Program in the environment sector in the European Community [7].

Many of the approved by the EC decisions (*annex 5.3*) concern the promotion of a sustainable economic development of the EU, also relying on the integration of the environmental policies in the framework of other strategies (*Box 5.3*). As fundamental objectives, settled for the integration of the environment aspects in the Energy Strategy of the European Community (1998), has been established the following: promoting the energy efficiency and the energy conservation, the comprehensive utilization of the renewable energy sources and the diminution of the producing energy sources impact on the environment.

In order to implement these objectives the following actions are necessary: an intense co-operation between EU, the Member States and the relevant parts for a better information exchange; the popularization of the advanced experience and the effectuation of common studies (the ETAP program); promoting an energy policy (1998-2002) that would facilitate the utilization of the renewable energy sources (the ALTENER program); increasing the energy efficiency (the SAVE program) and a more extensive cogeneration utilization; the elaboration of the energy strategy in accordance with the provisions of the Kyoto Protocol, etc.

Box 5.3. *Strategies favoring the sustainable development*

– Integration of the environmental policies in the framework of the EU strategic development.
– The environment and the utilization of the manpower.
– The integration of the environmental policies in the energy strategy of the European Community.
– The implementation of the sustainable agriculture.
– The integration of the environment aspects in the developing countries.
– The integration of sustainable development in the co-operation strategy of the Community.
– The strategy for the integration of the environment protection in the common market.
– The strategy for the integration of the environment protection aspects implemented in the fishing policy.
– Integral addressing of the environment protection and of the sustainable development of the urban area.
– The integration of the environment aspects in the economic development strategy.
– The promotion of the sustainable development in the non-energetic industry.
- The integration of the environment and air transport aspects.

Among the decisions that also consolidate the framework of integrating the environment and energy strategies are the following: the Directive concerning large power plants operations, the Communication concerning the combined production of energy [COM (97)514 final] and the Disposition concerning the “offshore” installations of petroleum and gas obtaining. Both the promoted in the framework of the SAVE, ALTENER and JOULE-THERMIE programs, and the legislative steps concerning the taxation of the energy products, of the combustion of the wastes and pollutant emissions proceeded from the transport (the Auto-Oil program) played an important role.

It is to note that concrete steps have been taken with regard to the GHG emissions. In 1991, the first Strategy of the European Commission concerning the abatement of the CO_2 emissions, the improvement of energy efficiency and the promotion of the renewable energy sources has been elaborated; in accordance with the decision of the Council of Ministers 99/296/EC of 26.04.1999 (amendment to the decision 93/296/EEC of 24. o6.1993), the revising and improvement of the CO_2 and other GHG emissions monitoring was approved.

After signing the Kyoto Protocol (on April 29th, 1998), the European Union initiated numerous activities in the purpose of accelerating the ratification process and getting in force this important instrument [COM (99) 203]. One of the fundamental responsibilities of the Member States was the adoption and implementation of the policies and steps that would determine a considerable abatement of the GHG emissions level to 2005. A special emphasis was put on the taxation implementation and the adaptation of the transport and energy related decisions. The Member States were encouraged to promote the fiscal initiatives for the abatement of the GHG emissions and the improvement of the energy efficiency.

The Goteborg approval (May, 2001) of the main objectives of the "European strategy concerning the sustainable development" shows the especially important contribution of the European Community in the world sustainable development. These steps make up a preparation of the European Union for the Johannesburg meeting from 2002 (Rio + 10). The EU efforts made for the more efficient tackling of the caused by the climate change consequences also are placed in this context. This phenomenon is considered as one of the greatest environment and social-economic dangers that hover above the planet. For the purpose of respecting its obligations from the UN Framework Convention on Climate Change, in March 2000 the European Commission initiated the European Climate Change Program (ECCP), stimulating this way the elaboration of the strategies, as well as of the trade emissions scheme, to assure in the 2008-2012 period the GHG emissions reduction with 8% - stipulated in the Kyoto Protocol objective. The stipulated by this program activities concern the energy, the transport, the industry and the agriculture, being realized in the framework of seven working groups: the energy supply, the energy consumption, transport, industry, researches, agriculture, mechanisms for the realization of the Protocol stipulations – the trade of the emissions, Joint Implementation and Clean Development Mechanism.

In the Communication of the European Commission [COM (2001) 580 final of 23.10.2001] concerning the realization of the first phase of the ECCP, numerous steps for reaching the mentioned objectives were proposed, including the ratification of the Kyoto Protocol and the issuing of a Directive concerning the emissions trade in the EU. These steps have been grouped in four compartments: inter-sectoral aspects, energy, transport and industry (*Box 5.4*).

Box 5.4. *Steps for implementing the ECCP objectives*

INTER-SECTORAL ACTIVITIES

– The Commission will assure the efficient implementation of the Directive concerning the warning and integrated control of the pollution (IPPC).

– The Commission will complete the Frame Directive concerning the trade of the emissions, in the first half of 2003.

– To the end of 2002, the Commission will propose an amendment to the CO_2 and other GHG emissions monitoring mechanism in accordance with the specified in the Kyoto Protocol exigencies.

ENERGY SECTOR

– The framework directive concerning the minimal level of energy efficiency of the electric equipment.

– The directive concerning the energy demand management through which the Member States will have to assure a minimum of investments in the energy efficiency.

– The directive concerning the combined energy generation.

– The initiative concerning the increase of the public energy acquisitions, which would promote the energy efficient technologies demand.

– Consciousness activities.

TRANSPORT

– The White Paper of the "Strategy concerning the public transport" contains a number of steps, concerning the GHG emissions abatement:

– Changing the relation between the types of transport, supporting the promotion of the railway and naval transport.

– The improvement of the infrastructure by settling balanced prices between different types of transport.

– The directive concerning the bio-fuel use.

INDUSTRY

– The framework directive concerning the abatement of the emissions and the improvement of the chlorofluorocarbons monitoring.

ADDITIONAL STEPS

– ECCP proposed for the selection 42 additional steps, of the most relevant the following could be named: the heat production using the RES, the energy management and audit, bringing up-to-date the engines, signing an agreement with the automobile industry concerning vehicles production, etc.

The performed by the EU activities in the framework of the UN Framework Convention on Climate Change contributes a lot to the GHG emissions reduction and to a world implementation of the Conventions objectives.

We mention that there were identified many parallels between the Rio Conventions (Convention on Biodiversity (UNCBD), the United Nations Framework Convention on Climate Change (UNFCCC) and the United Nations Convention to Combat Desertification (UNCCD)), and other conventions, that address the environment protection problem, and also that of sustainable economic development and poverty diminution in the developing countries.

As a logic continuation of the mentioned actions, the recent ratification of the Kyoto Protocol by the EU comes.

To facilitate the co-operation in the sector of the environment protection in the EU and the developing countries, EU established a legal framework by approving the payments for the integration of the environment aspects and economic development. In accordance with the Settlement 722/97/EC of the Council of Ministers established the necessary framework for community assistance offering (for the period until 31.08.1999) to the developing countries for the integration of the environment problem in the development process. Trough the approval of the Regulation 2493/2000/EC by the European Parliament, the European Community stipulated the continuous support of the co-operation with the developing countries for the period until 2006.

5.2. Policies and strategies in the Republic of Moldova

I. The energy sector

The institutions responsible for elaboration and promotion of energy policies

The Government elaborates proposals of legislative acts, adopts strategies, programs and energy related plans. In 1993-1999, the energy policy of the State, at the ministry level, was promoted by the *State Department for Energy, Energy Resources and Fuel.* In the previous Government (until April 2001), the responsible structure in this sector was the Ministry of Industry and Energy, and at present – the Ministry of Energy.

The Ministry of Energy, as an authority of the central public administration, promotes the State policy in the sector of energy by monitoring the implementation of concepts, strategies and programs for the development of the energy sector, elaborates normative documents, co-ordinates and administrates the activity of the energy enterprises with state capital, etc.

In 1997, the Government founded the *National Agency for Regulations in Energy (NAER)*, as a state body, responsible for the forming and operation of national energy market. One of the main functions of NAER is to elaborate the necessary normative framework for the good operation of the energy market, to implement the tariff policy.

In 1994 the *National Agency for Energy Conservation (NAEC)* was created, which assigned to elaborate strategies, programs, plans, as well as normative documents in the area of energy efficiency and energy conservation.

It is to note that the standards concerning the energy quality, the protection of the consumers are elaborated and adopted by the *State Department for Standardization and Metrology.*

For re-structuring the energy sector and further privatization the energy objectives, during the past years, a number of energy policy documents has been elaborated – strategies, programs, action plans and intervention instruments (legislative and regulation documents, etc.).

Energy strategies and programs

One of the most important energy policy documents is *the Long-term Energy Strategy of the Country* [19] that indicates the priority directions of developing the energy sector and objectives for a further future. The present strategy, approved in 2000, sets the following strategic objectives that must be reached by 2010:

– the finalization of the energy sector privatization and forming the energy market;
– promoting the energy efficiency and the energy conservation;
– assuring the energy security;
– environment protection.

These objectives will be reached by forming legislative, organizational, fiscal and other frameworks that would assure an efficient and long-term operation and development of the energy sector.

The mission of the State, according to the strategy, is to create and assure the necessary conditions for an efficient activity of the energy enterprises, regardless of their kind of ownership, with the purpose to provide continuous and qualitative supply of the consumers with energy and fuel, at reasonable tariffs and with an admissible impact on the environment.

In 2001, the Government of the Republic of Moldova adopted *the Strategy of Social-Economical Development till 2005* that includes *the Long-term Energy Strategy of Middle Period* [25], in which a number of energy objectives and priorities, co-related with the social-economic development has been settled. So, they are:

– Perfecting and developing the normative framework in all spheres of the energy sector, with alignment to the European standards;

– Re-structuring the energy sector, finalizing the enterprises privatization process and forming a competitive energy market;
– Increasing the energy efficiency by promoting a consequent policy of energy conservation, including the utilization of the renewable energy sources;
– Attraction of investments for the rehabilitation and construction of energy objectives, etc.

The energy security remains a vital problem and one of the most difficult for the Republic of Moldova. Taking into consideration the sustainable development, the energy sector will need a re-modeling, in accordance with the stipulations of the "Sustainable Development Strategy – Moldova 21":

– Getting a reliable satisfaction of the demands of the society at reasonable prices;
– Reducing the specific consumption (per unit of raw material, product and time);
– Giving up the energy intensive technologies;
– Re-structuring the economy;
– Changing the consumption models.

These performances will be reached in case of the following objectives are reached:

– The increase of the security supply and the operation reliability of the energy system;
– Raising efficiency of the consumption in the purpose of energy conservation;
– Maximal utilization of the alternative sources;
– Stimulation of the transition to a de-centralized energy system, based on modern technologies and the renewable energy sources utilization.

The long-term energy security of the State may be consolidated by building-up own capacities and by diversifying the import. The national energy policy corresponds, in general terms, with the general-European tendencies of transforming the energy sector in a competitive, efficient and sustainable system. The existing normative-legislative framework that supports this orientation must be extended, especially concerning: (a) the construction of new capacities and the extension of the existing ones (sources, networks), (b) imposing some energy and environment efficiency requirements (standards), (c) elaboration of national programs for energy conservation, first, in the public sector.

Implementation of the renewable energy sources

In the energy balance of the Republic of Moldova for 2000 [24], the total energy consumption made up 2,818 thousand t.c.e., of which 19 thousand t.c.e. (0,7%) were produced at the hydro-power plants as electricity, and 103 thousand t.c.e. (3,6%) – proceeded from the firewood and agricultural residues. So, the own energy sources in the energy balance of the country made up 4,3%, all of them proceeded from RES, and the imported ones, respectively - 95,7%.

This incontestable reality should place the Republic of Moldova among the candidate states for the massive utilization of the RES. Until present, the Republic of Moldova failed in the active promotion of the strategies and policies concerning the RES implementation, especially of the steps for encouraging the producers and the local investors. Though, this component part of the national energy system was tackled in a number of legislative documents:

- The Energy Strategy of the Republic of Moldova until 2010, approved by the Government Resolution No. 360 of 11.04.2000.
- The Law of the Republic of Moldova on Energy Conservation No. 1136-XIV of 13.07.2000.
- The Resolution of the Government of the Republic of Moldova No. 1092 of 31.10.2000, concerning the Utilization of the Renewable Energy Sources.
- The National Strategy for Sustainable Development: Moldova XXI.
- The first National Communication of the Republic of Moldova elaborated under the framework of the United Nations Convention on Climate Change.

Out of the provisions of the *Energy Strategy* and of the experts' estimations it results that near 2010 the RES quota part in the total energy consumption will make up about 10% [23, 25]. So, according to the *Republic of Moldova Energy Strategy,* the total fuel and electricity consumption will make up about 6,5 mil. t.c.e. in 2010 of which RES will cover about 650,000 t.c.e. [25] (*Figure 5.4).*

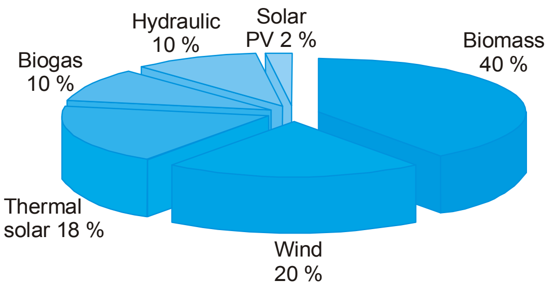

Figure 5.4. *The forecast of the different sources quota in the total energy production from the RES*

The following installations are considered to have the priority for the implementation in the Republic of Moldova:

- Large wind aggregates (the installed capacity higher than 500 kW) connected to the network.
- Small wind aggregates (1-5 kW) for the mechanic pumping of the water.
- Small wind aggregates (1-10 kW) for thermal supply.
- Solar installations for water heating in the rural area and fruit and vegetables drying.

The autonomous PV installations for supplying the territorially scattered small consumers (for example, the water pumping, the anti-hail stations, telecommunications, etc.).

These forecasts may turn to reality only provided the political willpower is manifested at all the government levels and coordinated efforts are made for the mobilization of the State financial, human, technical and technological resources.

Concomitantly, the necessity to elaborate a similar with the EU adopted well-founded State strategy concerning on RES implementation [26] is felt. To initiate the exploitation of these energy generating sources, it is necessary to create an appropriate legislative framework, by adopting the National Program of RES implementation that is being elaborated. This program will reflect the following aspects: legislative, institutional, educational and technological.

The strategic aspect of the Republic of Moldova's joining the European Union concerns the realization of the Article No. 60 "Energy" of the Partnership and Cooperation Agreement between the European Community and the Republic of Moldova. The cooperation will take place on the basis of the market economy principles, of the Energy Chart principles and on the background of the progressive integration of the energy markets from Europe.

II. Environment policies

The fundamentals of the environmental policies for the period of transition to the market economy were established by the Law on Environment (1993), the Concept on the Environment Protection in the Republic of Moldova (1995), the National Strategic Action Program in the Environment Protection Sector (1995); the National Action Plan on Environmental Protection and the National Action Plan for Health Related to the Environment (2001).

At present, there are a number of legislative documents *(Annex 5.4)* that form the necessary framework for promoting the activities concerning the environment protection and form the necessary premises for integrating the environmental policies in the energy strategies. A following step in perfecting the legislative framework would be the conception of institutional mechanisms to promote the market economy principles in the energetic industry (de-monopolization, privatization, decentralization, transparency) and the harmonization of the respective framework with the European legislation in the environment protection sector.

The National Sustainable Development Strategy of the Republic of Moldova (2000) had also been elaborated. This document includes the parameters of the social-economical system development, taking into consideration the natural capital potential and the environment protection for a 20 years period. In this period, the Republic of Moldova will have to affirm its capacity to realize a sustainable economic development and to obtain a social stability.

The necessity to promote a unitary environment and using the natural resources policy, to implement the ecological requirements in the process of reforming the national economy, the political orientation towards a European integration – all these conditioned the revision of the environment policy and the elaboration of a new conceptual document in this sector. In this way, the Environment Policy Concept of the Republic of Moldova (approved by the Resolution of the Parliament of the Republic of Moldova No. 605-XV of the 2nd of November 2001) to harmonize the major objectives of the ecological policy with the social-economical changes of the country, with the regional and world programs and tendencies in this sector, to warn the degradation of the environment quality.

The main objectives of the environmental policy are:

a) warning and reducing the negative impact of the economical activity on the environment factors, the natural resources and population's health, in the context of a sustainable development of the country;

b) assuring the ecological security of the country.

At present, the priority directions of the environment policy of the Republic of Moldova are the following:

1. The consolidation of the capacities in this sector and the inter-sectoral collaboration, which stipulate:
   a) the implementation of the "economy through ecology" and "cost-benefit" principles,
   b) the consolidation of the institutional and managerial potential.
2. The regulation of the impact, preventing the pollution and the environment edification, that foresee:
   a) the environment management in the enterprises and the ecological certification,
   b) the rehabilitation and maintenance of the natural potential.

In accordance with the above-named concept, the environment protection requirements will be integrated in the economical reform and in the sector policies. In this way, the priorities concerning the waste management, the diminution and collection of the harmful emissions, the increase of the energy efficiency, the utilization of the renewable energy sources *(Annex 5.5)* and widening the spectrum of researches on climate changes will be also taken into consideration. All these, as well as other components of the environmental policies, will determine a sustainable social-economic development.

The Republic of Moldova joins more and more actively the UNFCCC promoted activities. The first National Communication that includes the inventory of the GHG emissions and estimations concerning the social-economical impact of the GHG emissions effect has been elaborated and presented. In this document, the main actions to alleviate the climate changes impact are also indicated. Signing the Kyoto Protocol is being prepared, so that the promoted activities correspond to the provisions of the Environment Policy Concept, where the necessity of "implementing the stipulations of the United Nations Framework Convention on Climate Change and those of the Kyoto Protocol" is foreseen.

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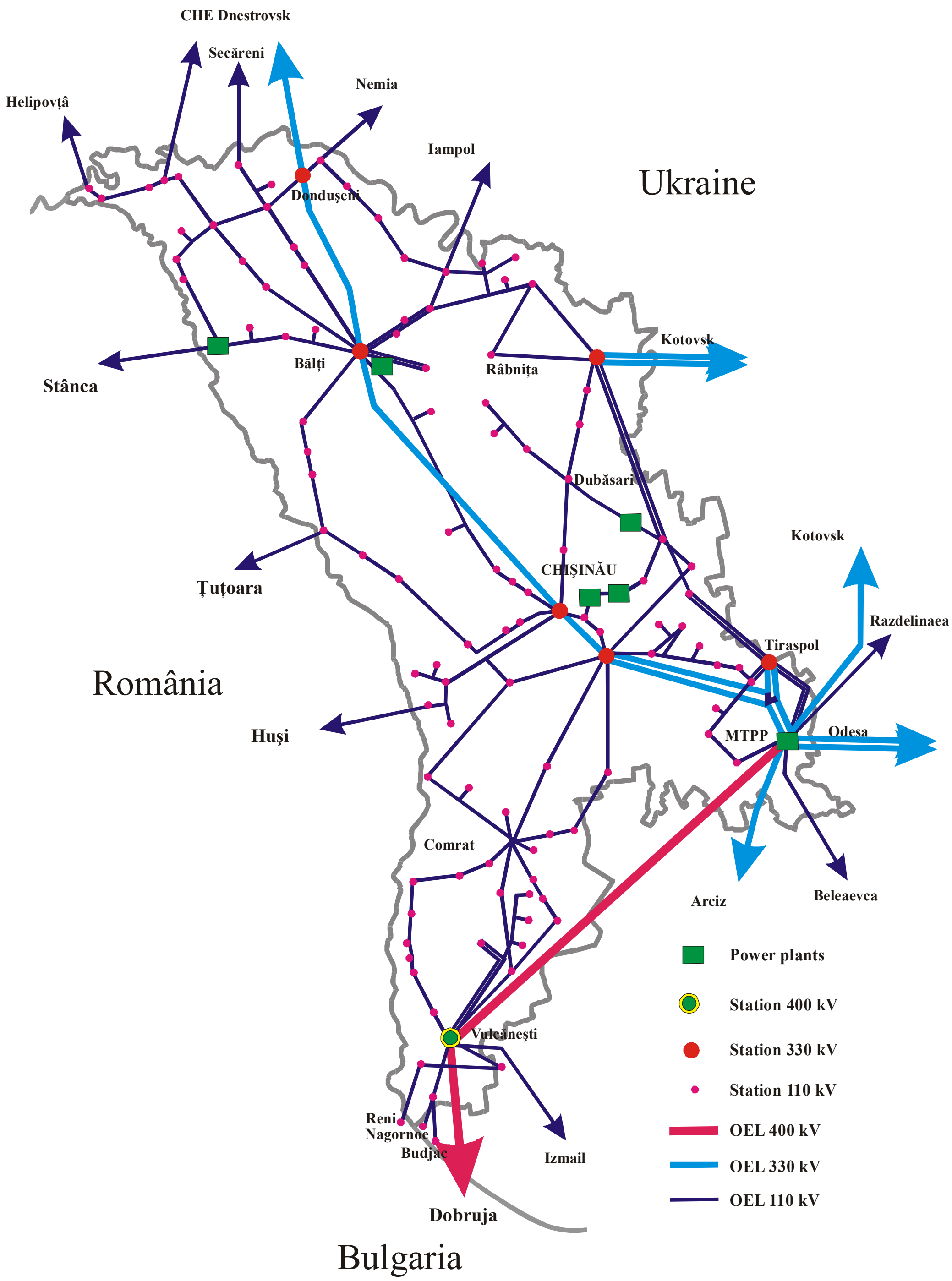
[22] The Law on the energy system, No. 1525-XIII, of 19/02/1998 (original in Romanian)

[23] The Law on energy conservation, No.,. 1136-XIV of 13/07/2000 (original in Romanian)

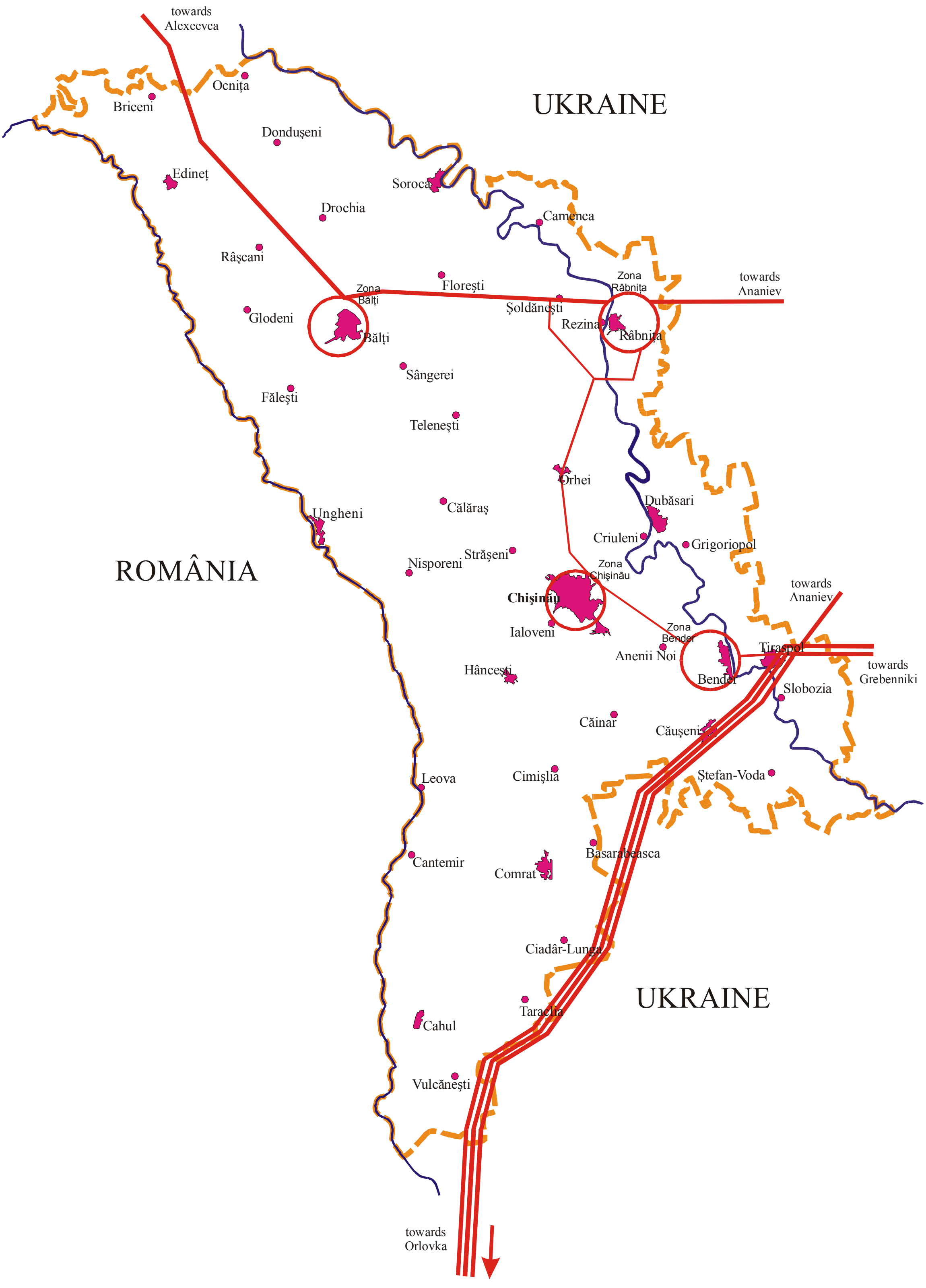
[24] The energy balance of the Republic of Moldova in 2000. The Statistic and Sociology Department of the Republic of Moldova. The Ministry of Energy. Chişinău, 2001 (original in Romanian)

[25] The strategy for social-economic development of the Republic of Moldova until 2005, approved by the Government Resolution No. 1415 of 19.12.2001. (original in Romanian)

[26] COM (1997) 599 final, Energy for the Future: Renewable Sources of Energy – White Paper for a Community Strategy and Action Plan.



Annex 1.1. *The scheme of electrical networks of 110-400 kV of the national power sector*



Annex 1.2. *International gas pipelines that cross the territory of the Republic of Moldova*

Annex 1.3. *Evolution of prices and natural gas tariffs (1992-2001), MDL less VAT*

Date of tariff enforcement	Population	Budget funded organizations	APR "Termocomenergo"	Agricultural farms	Other consumers
02.01.1992	*0.428*	–	*0.46*	*0.46*	*0.46*
01.03.1992	*0.428*	–	*1.566*	*1.566*	*1.566*
01.06.1992	*1.712*	*3.55*	*3.55*	*3.55*	*2.663*
01.12.1992	*3.24*	*3.74*	*3.74*	*3.74*	*4.126*
01.02.1993	*18.3*	*21.055*	*21.055*	*21.055*	*28.957*
01.05.1993	*27.2*	*37.98*	*37.98*	*37.98*	*52.246*
01.11.1993	*124*	*130.44*	*130.44*	*130.44*	*176.016*
01.12.1993	*124*	*148.01*	*148.01*	*148.01*	*203.8*
01.01.1994	*320.88*	*337.76*	*337.76*	*337.76*	*465.08*
01.04.1994	*320.88*	*435.47*	*452.45*	*452.45*	*571.08*
01.08.1994	*281.47*	*402.98*	*416.48*	*416.48*	*433.61*
01.03.1995	*281.47*	–	–	–	*346.21*
01.03.1997	*324*	–	–	–	*398*
01.06.1997	*454*	–	–	–	*454*
01.10.1998	*370*	–	–	–	*370*
24.12.1998	*638*	–	–	–	*638*
01.07.1999	*926*	–	–	–	*926*

Annex 1.4. *Evolution of prices and tariffs for electricity (1993-2001), bans (100 bans = 1 MDL) less VAT*

Date of tariff enforcement	Industry	Urban electrical transport	Urban population	Rural population	Sole tariff	Union Fenosa	EDN North, EDN North-West
10.11.1993	*0.08*	*0.03*	*0.04*	*0.03*	–	–	–
10.03.1994	*23.11*	*9*	*10*	*8*	–	–	–
01.03.1995	*18.5*	*9*	*10*	*8*	–	–	–
01.05.1996	*21*	*10*	*15*	*12*	–	–	–
01.03.1997	*23*	*15*	*20*	*16*	–	–	–
01.06.1997	–	–	–	–	*24*	–	–
01.10.1998	–	–	–	–	*25.5*	–	–
24.12.1998	–	–	–	–	*42*	–	–
01.07.1999	–	–	–	–	–	*50*	*50*
01.04.2000	–	–	–	–	–	*65*	*57*
01.10.2001	–	–	–	–	–	*68*	*65*

Annex 1.5. *Evolution of prices and tariffs for thermal energy (1993-2001), MDL less VAT*

Date of tariff enforcement	Hot water	Steam
15.01.1993	9.29	7.04
01.03.1993	12.08	13.53
10.07.1993	25.91	29
10.11.1993	99.16	111.06
10.03.1994	301	337.2
01.03.1995	271.55	309.6
01.05.1996	271.55	309.6
01.03.1997	271.55	309.6
01.06.1997	165	190
01.11.1998	126	150
24.12.1998	189	225
01.07.1999	233	260
21.12.2000	300	330

Annex 1.6. *Capacities structure at the Moldovan TPP*

Energy group	Utilized fuel	Year of setting into operation	Installed capacity, MW
1	coal	1964	200
2	coal	1965	200
3	coal	1966	200
4	coal	1966	200
5	coal	1967	200
6	coal	1967	200
7	coal	1970	200
8	coal	1971	200
9	residual fuel oil	1973	210
10	residual fuel oil	1974	210
11	gas	1979	245
12	gas	1980	245

Annex 1.7. *Features of steam boilers used at thermal plants*

Type of boiler	Capacity, t/h	Type of fuel	Specific consumption, kg.c.e./GJ	Efficiency
E -1/9	1.0	natural gas	36.2	0.81
		residual fuel oil	38.5	0.76
		coal	45.1	0.65
DE-4/14	4.0	natural gas	32.2	0.91
		residual fuel oil	34.0	0.86
DE-10/14	10	natural gas	32.5	0.90
		residual fuel oil	33.9	0.86
DE-25/14	25	natural gas	31.8	0.92
		residual fuel oil	33.3	0.88
DKVR-2.5/13	2.5	residual fuel oil	33.7	0.87
DKVR-4/13	4.0	natural gas	32.5	0.90
		residual fuel oil	34.2	0.86
DKVR-6.5/13	6.5	natural gas	33.3	0.88
		residual fuel oil	34.9	0.84
DKVR-10/13	10	natural gas	32.9	0.89
		residual fuel oil	32.2	0.91
DKVR-20/13	20	residual fuel oil	32.5	0.90

Annex 1.8. *The features of the large hot-water boilers*

Type of boiler	Capacity, MW	Type of fuel	Specific consumption, kg.c.e./GJ	Efficiency
KV-GM-10	12	natural gas	31.9	0.919
		residual fuel oil	33.1	0.884
KV-GM-20	23	natural gas	31.9	0.919
		residual fuel oil	33.3	0.880
KV-GM-30	35	natural gas	32.1	0.912
		residual fuel oil	33.4	0.877
KV-GM-50	58	natural gas	31.7	0.925
		residual fuel oil	32.2	0.911
KV-GM-100	116	natural gas	31.6	0.926
		residual fuel oil	32.1	0.913
KV-GM-180	210	natural gas	32.0	0.917
		residual fuel oil	32.3	0.908
PTVM-30	35	natural gas	32.5	0.901
		residual fuel oil	33.3	0.879
PTVM-50	58	natural gas	32.7	0.897
		residual fuel oil	33.4	0.878
PTVM-100	116	natural gas	33.1	0.886
		residual fuel oil	33.8	0.868

Annex 1.9. *The features of the small capacity hot water boilers*

Type of boiler	Type of fuel	Specific consumption, kg.c.e./GJ	Efficiency
Fakel	natural gas	32.4	0.91
	residual fuel oil	37.6	0.78
Universal	natural gas	41.8	0.70
	coal	45.8	0.64
Bratsk	natural gas	32.2	0.91
Minsk	natural gas	35.7	0.82
	residual fuel oil	45.8	0.64
	coal	47.2	0.62
Başenergo	residual fuel oil	41.8	0.70
Tula	coal	45.8	0.64
KVG	natural gas	31.8	0.92
KVGM	residual fuel oil	33.3	0.88
TG	natural gas	32.2	0.91
KC	natural gas	32.5	0.90
KV	natural gas	35.7	0.82
KVM	residual fuel oil	41.8	0.70
KVT	coal	41.8	0.70
PTVM	natural gas	32.8	0.89
	residual fuel oil	33.6	0.87

Annex 1.11. *Emission factors used in evaluation of GHG emissions, t_{GHG}/TJ*

Fuel / Pollutants	Coal	Residual fuel oil	Natural gas
CO_2	92.70	76.56	55.87
CH_4	0.001	0.003	0.001
N_2O	0.0014	0.0006	0.0001
NO_x	0.30	0.20	0.15
CO	0.02	0.02	0.02
COVNM	0.005	0.005	0.005
SO_2	3.0	1.5	–

Annex 1.10. *Global warming potential of GHG for different time horizons*

GHGs	Atmospheric lifetime, years	GWP20	GWP100	GWP500
CO_2 (Carbon dioxide)	100-200	1	1	1
CH_4 (Methane)	12-17	56	21	6.5
N_2O (Nitrous dioxide)	120	280	310	170
$CFCl_3$ (CFC-11)	45-55	5,000	4,000	1,400
SF_2Cl_2(CFC-12)	102	7,900	8,500	4,200
CF_2HCl(HCFC-22)	13.3	4,300	1,700	520
CHF_2CHF_2 (HFC-134)	11.9	3,100	1,200	370
$C_2H_4F_2CHF_2$ (HFC-152a)	1.5	460	140	44
CO (Carbon monoxide)	0.3	–	–	–
NMVOC (Non-methane hydrocarbons)	0.1 - 0.3	–	–	–
C_xH_y (hydrocarbons)	< 0.1	–	–	–
NO_x (nitrogen oxides)	1-7 days	–	–	–

Annex 1.12. *The evolution of fuels consumption and direct GHG emissions at the CHPs*

Indices / Year	Fuel consumption, TJ				Emissions of GHGs in terms of CO_2 equivalent, Gg			
	CHP-1	CHP-2	CHP-North	CHP-SF	CHP-1	CHP-2	CHP-North	CHP-SF
1990	9,781.3	16,376.6	7,023.2	8,257.4	581.8	954.3	529.6	634.2
1991	11,272.0	14,051.5	7,366.4	7,165.4	684.5	818.8	511.1	550.4
1992	9,566.5	11,204.4	5,887.0	6,956.8	581.2	653.0	367.0	534.3
1993	7,107.1	10,636.4	4,248.9	5,726.9	430.8	619.8	262.6	439.9
1994	5,761.0	10,557.0	3,474.5	4,280.6	341.9	615.2	205.3	306.3
1995	4,976.2	9,061.9	3,249.9	4,583.8	296.2	528.0	195.3	326.7
1996	4,512.1	10,817.1	3,666.6	5,280.7	272.5	630.3	214.6	356.2
1997	3,933.2	12,939.7	3,197.4	4,612.8	231.2	754.0	187.1	309.7
1998	4,704.6	10,175.8	2,633.9	3,902.1	276.9	592.9	158.5	254.4
1999	2,623.7	10,440.7	1,728.7	5,488.2	155.9	608.4	108.2	348.0
2000	2,247.4	8,989.0	878.6	5,632.1	131.9	523.8	51.9	358.4

Annex 1.13. *The evolution of specific consumption and GHG emissions proceeding directly from CHPs*

Year	CHP-1		CHP-2		CHP-North	
	Specific consumption of fuel, t.c.e./TJ	Emission of CO_2 equivalent, t/TJ	Specific consumption of fuel, t.c.e./TJ	Emission of CO_2 equivalent, t/TJ	Specific consumption of fuel, t.c.e./TJ	Emission of CO_2 equivalent, t/TJ
1990	*30.0*	*46.5*	*19.2*	*26.6*	*34.6*	*73.3*
1991	*28.3*	*48.8*	*22.3*	*27.3*	*35.5*	*69.5*
1992	*28.0*	*48.4*	*21.4*	*22.2*	*34.3*	*60.7*
1993	*31.9*	*56.3*	*20.1*	*22.8*	*33.8*	*59.3*
1994	*30.7*	*51.8*	*17.9*	*24.8*	*33.4*	*56.2*
1995	*30.3*	*51.4*	*16.9*	*22.4*	*32.8*	*56.1*
1996	*30.5*	*52.4*	*19.6*	*25.9*	*33.2*	*55.4*
1997	*27.3*	*45.7*	*23.0*	*33.0*	*35.7*	*59.5*
1998	*25.3*	*42.4*	*18.6*	*27.2*	*36.2*	*62.0*
1999	*19.9*	*33.7*	*21.2*	*32.3*	*39.5*	*70.2*
2000	*19.4*	*32.5*	*21.3*	*33.4*	*38.5*	*64.8*

Annex 1.14. *Technical-economic performances obtained in cases of some implementation scenarios on the territory of the Republic of Moldova of medium and small capacity CHPs with GSTI on natural gas*

Locality	CHP with GSTI	Capacity		Annual average efficiency	Total cost	Cost of equipment	Specific cost	Gas consumption
		Electrical	Thermal					
		MW		%	USD mil.		USD/kW	mil. m³/year
Briceni	ITGA-24	*24*	*17.4*	*56*	*14*	*11*	*585*	*41.5*
Edineț	ITGA-24	*24*	*17.4*	*56*	*14*	*11*	*585*	*41.5*
Drochia	ITGA-24	*24*	*17.4*	*56*	*14*	*11*	*585*	*41.5*
Râşcani	ITGA-24	*24*	*17.4*	*56*	*14*	*11*	*585*	*41.5*
Glodeni	ITGA-24	*24*	*17.4*	*56*	*14*	*11*	*585*	*41.5*
Bălți	ITGA-70	*70*	*52.2*	*62*	*29.6*	*20.3*	*425*	*100.6*
Floreşti	ITGA-38	*40.5*	*34.8*	*60*	*18.4*	*12.2*	*485*	*66.9*
Şoldăneşti	ITGA-38	*40.5*	*34.8*	*60*	*18.4*	*12.2*	*485*	*66.9*
Rezina	ITGA-38	*40.5*	*34.8*	*60*	*18.4*	*12.2*	*485*	*66.9*
Râbnița	ITGA-70	*70*	*52.2*	*62*	*29.6*	*20.3*	*425*	*100.6*
Orhei	ITGA-38	*40.5*	*34.8*	*60*	*18.4*	*12.2*	*485*	*66.9*
Străşeni	ITGA-24	*24*	*17.4*	*56*	*14*	*11*	*585*	*41.5*
Dubăsari	ITGA-24	*24*	*17.4*	*56*	*14*	*11*	*585*	*41.5*
Chişinău	ITGA-70	*70*	*52.2*	*62*	*29.6*	*20.3*	*425*	*100.6*
Tighina	ITGA-38	*40.5*	*34.8*	*60*	*18.4*	*12.2*	*485*	*66.9*
Tiraspol	ITGA-70	*70*	*52.2*	*62*	*29.6*	*20.3*	*425*	*100.6*
Căuşeni	ITGA-24	*24*	*17.4*	*56*	*14*	*11*	*585*	*41.5*
Cimişlia	ITGA-24	*24*	*17.4*	*56*	*14*	*11*	*585*	*41.5*
Ciadâr-Lunga	ITGA-38	*40.5*	*34.8*	*60*	*18.4*	*12.2*	*485*	*66.9*
Vulcăneşti	ITGA-38	*40.5*	*34.8*	*60*	*18.4*	*12.2*	*485*	*66.9*
Cahul	ITGA-38	*40.5*	*34.8*	*60*	*18.4*	*12.2*	*485*	*66.9*
Comrat	ITGA-38	*40.5*	*34.8*	*60*	*18.4*	*12.2*	*485*	*66.9*
Basarabeasca	ITGA-24	*24*	*17.4*	*56*	*14*	*11*	*585*	*41.5*
Taraclia	ITGA-24	*24*	*17.4*	*56*	*14*	*11*	*585*	*41.5*
Grigoriopol	ITGA-24	*24*	*17.4*	*56*	*14*	*11*	*585*	*41.5*
Total		**932.5**	**730.8**		**452**	**323**		**1.502.5**

Annex 2.1. *Evolution of fuels consumption by road transport, thousand tons (1990-2000)*

Year \ Fuel	Gasoline	Diesel oil	LPG	LNG
1990	*662.6*	*1005.6*	*14.0*	*13.1*
1991	*652.1*	*990.0*	*17.3*	*11.7*
1992	*363.9*	*684.4*	*10.4*	*5.7*
1993	*233.0*	*495.0*	*6.0*	*8.5*
1994	*214.0*	*390.0*	*3.3*	*7.5*
1995	*283.0*	*365.0*	*2.8*	*7.6*
1996	*225.0*	*353.6*	*2.4*	*8.1*
1997	*273.0*	*338.0*	*2.6*	*9.5*
1998	*221.0*	*269.8*	*2.7*	*9.4*
1999	*117.1*	*187.3*	*2.4*	*7.8*
2000	*121.2*	*200.3*	*1.5*	*9.2*

Annex 2.2. *Evolution of railway transportation (1990-2000)*

Year	Locomotives	Diesel trains
1990	*324*	*44*
1991	*320*	*44*
1992	*226*	*42*
1993	*165*	*36*
1994	*129*	*32*
1995	*113*	*29*
1996	*103*	*28*
1997	*97*	*26*
1998	*82*	*26*
1999	*80*	*24*
2000	*76*	*22*

Annex 2.3. *Evolution of fuels consumption in the naval and air transport, thousand tons (1990-2000)*

Year	River transport - Diesel fuel consumption	Air transport - Aviation gasoline consumption
1990	*0.077*	*68.06*
1991	*0.076*	*73.86*
1992	*0.065*	*30.54*
1993	*0.075*	*19.70*
1994	*0.059*	*12.00*
1995	*0.057*	*13.30*
1996	*0.062*	*20.90*
1997	*0.067*	*20.40*
1998	*0.042*	*20.30*
1999	*0.053*	*15.00*
2000	*0.046*	*17.10*

Annex 2.5. *The dynamics of total direct GHG emissions resulted from fuel combustion within the transport sector, Gg CO_2 equivalent (1990-2000)*

Year	Road	Railway	Air	Naval	Total
1990	*4,876.4*	*461.8*	*217.3*	*0.25*	5,555.6
1991	*4,865.4*	*394.2*	*232.7*	*0.24*	5,492.5
1992	*3,085.0*	*274.3*	*96.2*	*0.21*	3,455.7
1993	*2,110.8*	*206.2*	*32.1*	*0.24*	2,379.3
1994	*1,728.0*	*211.8*	*37.8*	*0.19*	1,977.7
1995	*1,921.2*	*147.3*	*41.9*	*0.18*	2,110.6
1996	*1,719.8*	*136.4*	*65.9*	*0.20*	1,922.3
1997	*1,831.1*	*127.8*	*75.6*	*0.22*	2,034.8
1998	*1,459.8*	*119.7*	*72.5*	*0.14*	1,652.0
1999	*917.7*	*74.0*	*47.3*	*0.17*	1,039.2
2000	*975.6*	*80.8*	*53.9*	*0.15*	1,110.4

Annex 2.4. *Emissions factors used in evaluation of emissions proceeding from combustion of fossil fuels in the transport sector, g_{GHG} / kg_{fuels}*

Transport category	Type of fuels used	Pollutant					
		CO_2	CH_4	N_2O	NO_x	CO	NMVOC
Busses	Gasoline	*3014.5*	*0.914*	*0.057*	*24.94*	*570.31*	*52.87*
	Diesel oil	*3148.1*	*0.083*	*0.165*	*10.98*	*11.74*	*3.09*
	LNG	*2750.0*	*31.60*	–	*19.00*	*36.10*	*4.50*
	LPG	*3000.0*	*0.959*	–	*36.79*	*122.18*	*25.66*
Trucks	Gasoline	*3014.5*	*0.640*	*0.035*	*39.41*	*341.36*	*31.35*
	Diesel oil	*3148.1*	*0.252*	*0.120*	*42.41*	*35.69*	*7.98*
	LNG	*2750.0*	*27.80*	–	*63.90*	*22.20*	*5.60*
	LPG	*3000.0*	*1.200*	–	*16.80*	*70.60*	*23.50*
Cars	Gasoline	*3014.5*	*0.790*	*0.059*	*28.70*	*362.23*	*47.40*
Motorcycles		*3014.5*	*4.988*	*0.067*	*2.66*	*730.76*	*511.94*
Agricultural machinery	Diesel oil	*3188.0*	*0.450*	*0.080*	*63.50*	*25.40*	*9.60*
Locomotives		*3188.0*	*0.200*	*0.080*	*74.30*	*26.10*	*5.50*
Ships		*3188.0*	*0.200*	*0.080*	*67.50*	*21.30*	*4.90*
Airplanes	Aviation gasoline	*3149.0*	*0.100*	–	*12.50*	*5.20*	*0.78*

Annex 2.6. *Total NO_x emissions proceeding from the transport sector, Gg (1990-2000)*

Type of fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Gasoline	*21.85*	*21.52*	*12.00*	*7.34*	*7.054*	*9.34*	*7.43*	*8.83*	*7.13*	*3.70*	*4.02*
Diesel oil	*59.46*	*56.84*	*40.12*	*28.54*	*22.05*	*20.42*	*20.29*	*19.05*	*14.99*	*10.19*	*10.32*
LNG	*0.69*	*0.61*	*0.30*	*0.46*	*0.39*	*0.40*	*0.43*	*0.50*	*0.49*	*0.41*	*0.48*
LPG	*0.37*	*0.53*	*0.32*	*0.20*	*0.10*	*0.09*	*0.08*	*0.09*	*0.08*	*0.08*	*0.05*
Aviation gasoline	*0.86*	*0.92*	*0.38*	*0.25*	*0.15*	*0.17*	*0.26*	*0.30*	*0.29*	*0.19*	*0.21*
Total	**83.24**	**80.42**	**53.12**	**36.78**	**29.74**	**30.41**	**28.49**	**28.76**	**22.98**	**14.57**	**15.09**

Annex 2.7. *Total CO emissions proceeding from the transport sector, Gg (1990-2000)*

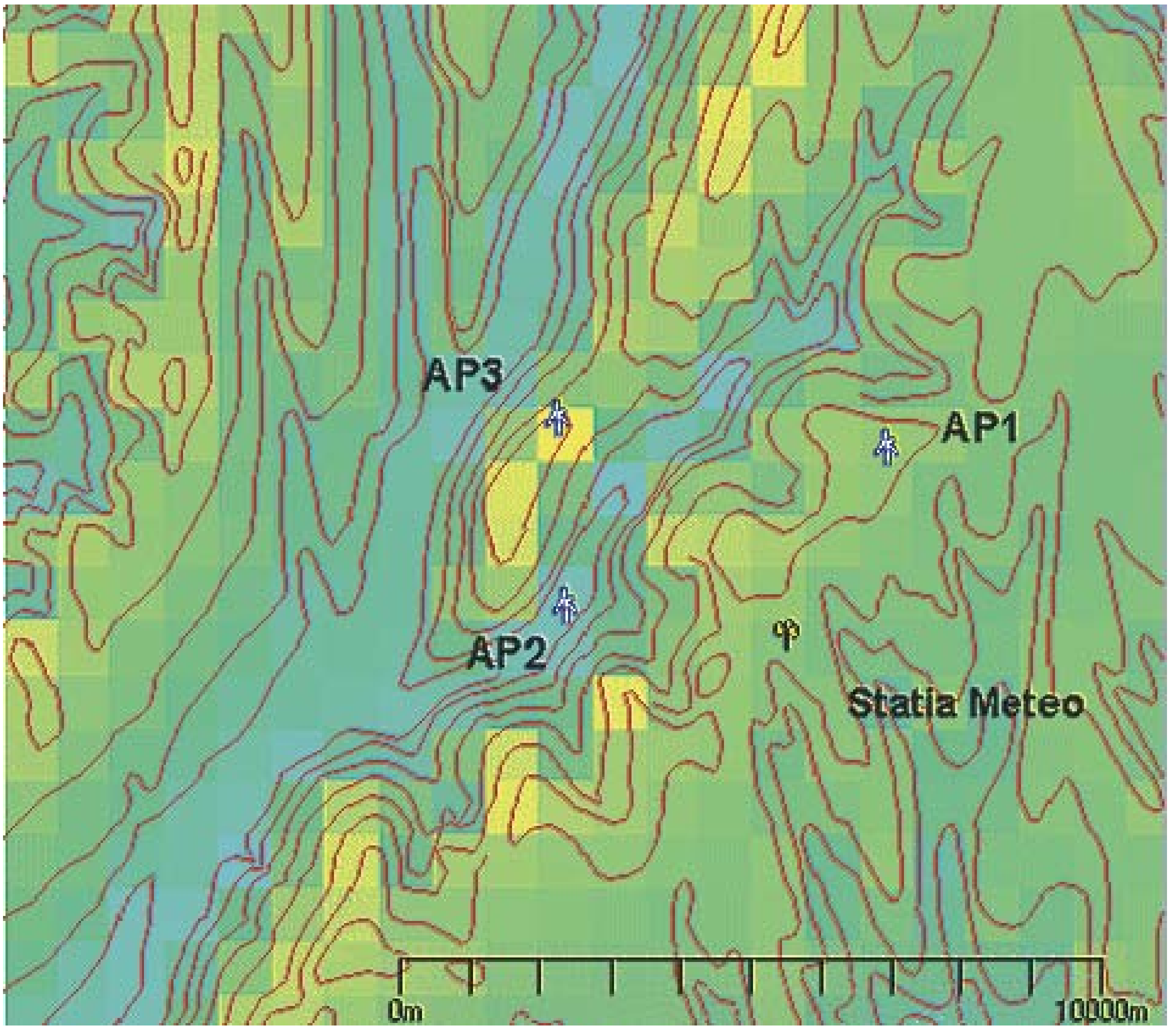
Type of fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Gasoline	*256.24*	*252.61*	*140.75*	*86.02*	*82.58*	*109.49*	*86.99*	*105.15*	*83.92*	*44.05*	*47.29*
Diesel oil	*25.54*	*25.13*	*17.37*	*12.55*	*9.88*	*9.25*	*8.94*	*8.58*	*6.84*	*4.75*	*5.08*
LNG	*0.34*	*0.30*	*0.15*	*0.21*	*0.19*	*0.19*	*0.21*	*0.24*	*0.24*	*0.20*	*0.24*
LPG	*1.35*	*1.84*	*1.11*	*0.67*	*0.34*	*0.31*	*0.27*	*0.29*	*0.29*	*0.26*	*0.16*
Aviation gasoline	*0.36*	*0.38*	*0.16*	*0.10*	*0.06*	*0.07*	*0.11*	*0.12*	*0.12*	*0.08*	*0.09*
Total	**283.82**	**280.26**	**159.53**	**99.56**	**93.06**	**119.31**	**96.52**	**114.38**	**91.41**	**49.34**	**52.86**

Annex 2.8. *Total NMVOC emissions proceeding from the transport sector, Gg (1990-2000)*

Type of fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Gasoline	*28.60*	*27.90*	*15.71*	*9.87*	*9.41*	*12.18*	*9.66*	*11.83*	*9.63*	*5.29*	*5.39*
Diesel oil	*8.16*	*7.88*	*5.57*	*3.94*	*2.95*	*2.82*	*2.82*	*2.65*	*2.05*	*1.40*	*1.41*
LNG	*0.07*	*0.06*	*0.03*	*0.05*	*0.04*	*0.04*	*0.04*	*0.05*	*0.05*	*0.04*	*0.05*
LPG	*0.34*	*0.43*	*0.26*	*0.15*	*0.08*	*0.07*	*0.06*	*0.07*	*0.07*	*0.06*	*0.04*
Aviation gasoline	*0.05*	*0.06*	*0.02*	*0.02*	*0.01*	*0.01*	*0.02*	*0.02*	*0.02*	*0.01*	*0.01*
Total	**37.23**	**36.33**	**21.59**	**14.02**	**12.49**	**15.12**	**12.60**	**14.61**	**11.82**	**6.81**	**6.90**

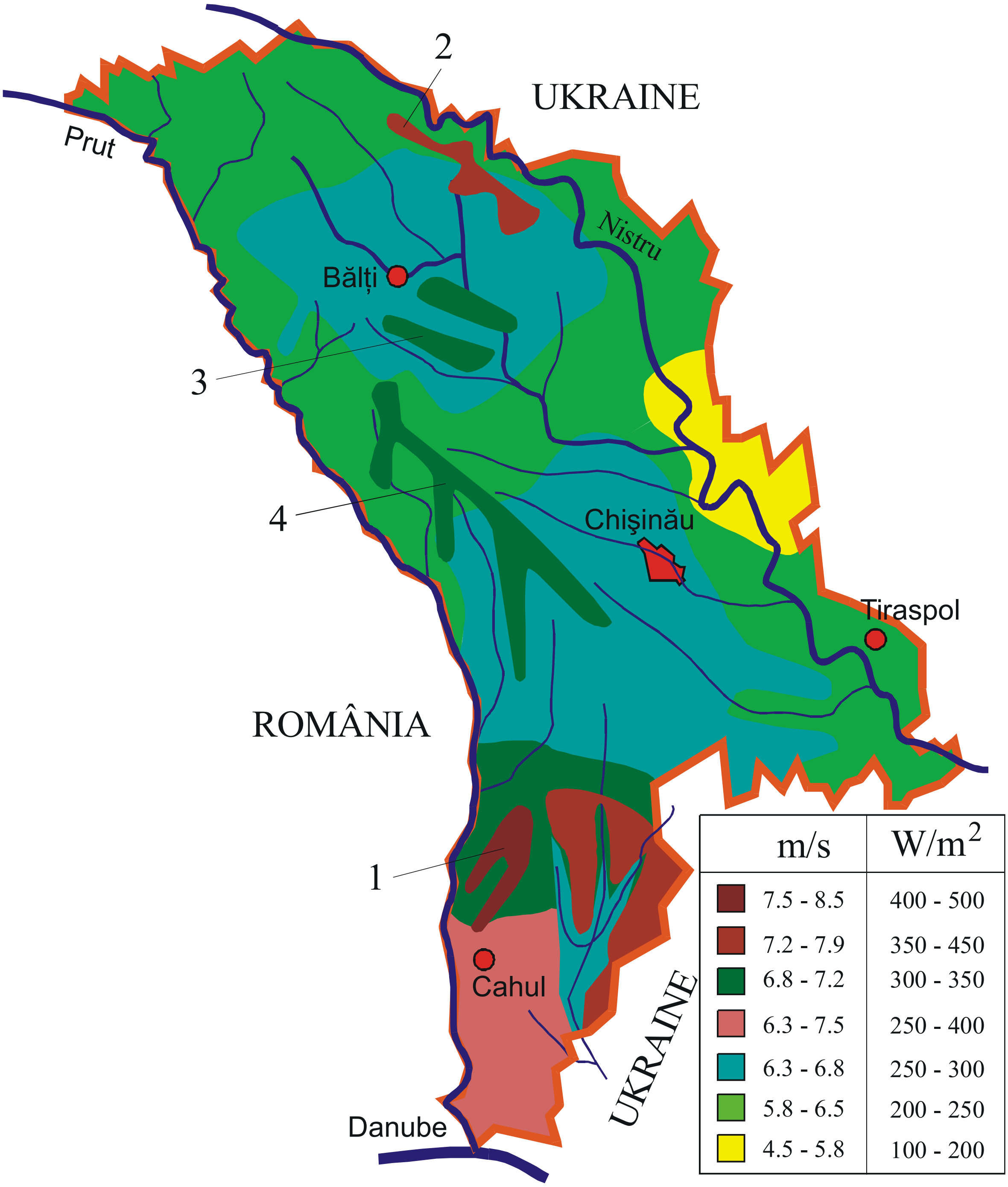
Annex 4.1. *Annual exploitation costs for biogas production*

Annual costs	Unit of measure	Total capacity, m^3		
		250	750	1,500
In kind costs drinking water (2.06 MDL/m^3)	m^3 thous. MDL/year	*100* *0.021*	*50,000* *10.3*	*50,000* *10.3*
In kind costs electricity (0.65 bans/kWh)	kWh thous. MDL/year	*3,360* *2.18*	*5,400* *3.51*	*7,400* *4.81*
Staff labor payment (4 individuals x 500 MDL / month x 12 months)	thous. MDL/year	*12*	*24*	*24*
Social insurance (35% of the payroll)	thous. MDL/year	*4.2*	*8.4*	*8.4*
Amortization costs (20% of the investments)	thous. MDL/year	*76.29*	*168.21*	*226.69*
Other costs (10%)	thous. MDL/year	*9.47*	*21.40*	*27.4*
Total annual costs	thous. MDL/year thous. USD/year	*102.82* *7.99*	*232.36* *18.05*	*297.34* *23.10*
The duration of capital investments pay-off	years	*50*	*13*	*6*
The coefficient of recovery of capital investments	$years^{-1}$	*0.02*	*0.08*	*0.17*



	10 m		25 m		50 m		100 m		200 m	
	m/s	W/m^2	m/s	W/m^2	m/s	W/m^2	m/s	W/m^2	m/s	W/m^2
(yellow)	5,35	171,3	6,18	246,1	7,02	330,5	8,20	503,3	10,01	941,0
(green)	4,92	131,1	5,84	205,7	6,72	287,1	7,94	454,6	9,83	887,3
(blue)	3,99	72,0	5,00	130,3	5,94	198,9	7,21	341,1	9,17	720,5

Annex 3.1. *The map of wind energy resources for a representative territory in the southern part of the Republic of Moldova*



Annex 3.2. *The map of the wind energy potential of the Republic of Moldova, at a height of 70 m above the ground*

Annex 5.1. *Energy policies and implementation mechanisms in the EU*

I. COOPERATION IN ENERGY SECTOR	
Objectives and actions	**Implementation/funding**
Cooperation with Member States ***Cooperation with interested parties***	*Cooperation framework* *Consulting committees*
II. COMMUNITY ACTIONS	
Objectives and actions	**Implementation/funding**
1. Energy security and international cooperation	
Diversifying supplies of energy: *relations with supplier-countries* *sources of energy* ***Actions in the field of consumption management.*** *Cooperation and assistance programs* *Technical assistance programs considering the European priorities in international energy cooperation* *New states preparation and adhering* *Cooperation with international institutions* *Crisis measures*	*European Energy Map* *Bilateral agreements* *Renewable energy sources, bio-fuels, nuclear energy* *SAVE/THERMIE Programs* *PHARE,TACIS, MEDA, Asia, Latin America (ALURE), EDF, SYNERGY Programs, including EuroMediteranian Forum and Special Commission for Balkans, China-EU group.* *Energy policy convergence* *International development of IEA, IAEA,EBRD, WB networks* *Adaptation of the existing network*
2. Energy markets integration	
Creation of domestic energy market ***Contributions to social and economic*** ***Providing investments in energy***	*Domestic markets for electricity and fuel gases* *Trans-European Energy Networks* *Competition policies* *Energy taxation* *Transparency on the energy market* *Standardization* *Structural Funds/ Social Consolidation* *EIB / EIF, FCSC*
3. Promotion of sustainable development in energy	
Encouraging efficient and rational usage of energy resources ***Promotion of new and renewable energy sources*** ***Compatibility between energy and environment objectives***	*SAVE program, including the domestic and regional agencies* *Strategy on renewable sources. ALTENER program* *Climate Change/suggestions in road-fuels / cooperation with the industry sector on abating* CO_2 *emissions*
4. Promotion of researches in energy sector and technological development	
Promotion of researches, presentation and dissemination of energy technologies ***Researches in the field of nuclear energy***	*JOULE / THERMIE / INCO* *EUROATOM*

Annex 5.2. *The structure of regulatory & legal framework in EU energy sector*

1. **General energy policy**
   – Investment projects;
   – European forum in energy and transport issues.
2. **Energy efficiency**
   – Towards a strategy for rational usage of energy;
   – Action plans;
   – SAVE program;
   – Requirements towards energy efficiency of devices and technologies.
3. **Domestic energy market**
   – Price transparency;
   – Transit of electricity through the systems;
   – Transit of natural gases through the systems;
   – Electricity and gas distribution;
   – Electricity common market;
   – Natural gas common market.
4. **Nuclear power**
   – Nuclear security in CIS, Central and Eastern European countries.
5. **Trans-European networks**
   – Declaration of interest in transportation of electricity and gas;
   – General rules on providing community financial assistance in trans-European networks;
   – Guide on trans-European energy networks;
   – Set of actions with regard to trans-European networks in the energy sector;
   – External dimension of trans-European energy networks.
6. **European programs**
   – Framework action program in the energy sector;
   – Cooperation with developing countries: SYNERGY program;
   – SURE program (nuclear security);
   – Multi-annual research program;
   – CARNOT (solid fuels) program.
7. **Renewable energy sources**
   – Directive;
   – ALTENER program for renewable energies promotion;
   – Green Paper;
   – White Paper for a community strategy and a common action plan;
   – Promotion of electricity production from renewable energy sources.
8. **Energy products taxation**
   – Community framework for energy products taxation;
   – Taxes for carbon dioxide emissions and energy.
9. **Energy security**
   – Green Paper
10. **Cooperation with developing countries**
11. **Energy dimension of climate changes**

Annex 5.3. *The main documents on European Energy Policy*

1. Treaty on the European Union
2. White Paper of the European Commission – An Energy Policy for the European Union, January 1996
3. COM (2000) 769. Towards a European Strategy for the Security of Energy Supply
4. COM (2001) 126 final. Enhancing Euro-Mediterranean Cooperation on Transport and Energy
5. COM (1997) 550 final. Multiannual Framework Programme for Actions in the Energy Sector
6. SEC (2001) 502. Commission staff working paper. Integrating Environment and Sustainable Development into Energy and Transport policies: Review Report 2001 and Implementation of the Strategies
7. Directive 98/30/EC. Common rules for the internal market in natural gas
8. Directive 96/92/EC. Common rules for the internal market in electricity
9. Council Directive 90/547/EEC. On the transit of electricity through transmission grids
10. Council Directive 73/238/EEC. On measures to mitigate the effects of difficulties in the supply of crude oil and petroleum products
11. COM (2000) 297 final. Recent Progress with Building the Internal Electricity Market
12. Directive 2000/55/EC. On energy efficiency requirements for ballasts for fluorescent lighting
13. Directive 96/57/EC. On energy efficiency requirements for household electric refrigerators, freezers and combinations thereof
14. Council Directive 92/42/EEC. Boilers Directive
15. Council Directive 89/106/EEC. Construction Products Directive
16. COM (1998) 246 final. Energy Efficiency in the European Community – Towards a Strategy for the Rational use of Energy
17. COM (2000) 247 final. Action plan to improve Energy Efficiency in the European Community
18. COM (1997) 514 final. A community strategy to promote combined heat and power (CHP) and to dismantle barriers to its development
19. COM (2001) 94 final. RTD Framework Programme
20. Council Resolution of 7 December 1998 on energy efficiency in the European Community
21. Council Resolution of 18 December 1997 on a Community strategy to promote combined heat and power
22. Directive 2001/77/EC. On the promotion of electricity produced from renewable sources
23. Directive 1991/31/EC. On the landfill of waste
24. Directive 2001/77/EC. On the promotion of electricity produced from renewable energy sources in the internal electricity market
25. Decision 646/2000/EC. A Multi-annual program for the promotion of renewable energy sources in the Community (Altener) (1998 to 2002)
26. Council Decision 1999/24/EC. A multi-annual program of technological actions promoting the clean and efficient use of solid fuels (1998 to 2002)
27. COM (1997) 599 final. Energy for the Future: Renewable Energy Sources of Energy – White Paper for a Community Strategy and Action Plan
28. COM (2000) 279 final. Proposal for a Directive of the European Parliament and of the Council on the promotion of electricity from renewable energy sources in the internal electricity market. (COM (2000) 279, amended COM (2000) 884)
29. COM (2000) 884. Promotion of electricity from renewable energy sources in the internal electricity market
30. Directive 94/22/EC. On the conditions for granting and using authorizations for the prospection, exploration and production of hydrocarbons
31. Directive 94/63/EC. On the control of volatile organic compound (VOC) emissions resulting from the storage of petrol and its distribution from terminals to service stations
32. Council Directive 88/609/EEC. On polluting emissions from large combustion plants
33. Council Directive 93/76/EEC. To Limit Carbon Dioxide Emissions by improving energy efficiency (SAVE)

34. A5-0039/1999. Environmental Integration within Community Energy Policy
35. COM (1998) 571 final. Strengthening Environmental Integration within Community Energy Policy
36. COM (1999) 230 final. Preparing for implementation of the Kyoto Protocol
37. COM (2001) 31 final. Sixth Environment Action Programme of the European Community
38. COM (2000) 88. EU Policies and Measures to Reduce Greenhouse Gas Emissions: Towards a European Climate Change Programme
39. COM (97) 30 final. Restructuring the Community framework for the taxation of energy products
40. COM (2000) 87 final. Green Paper on greenhouse gas emissions trading within the European Union
41. COM (2001) 579 Proposal for ratification of the Kyoto Protocol by the European Community
42. COM (2000) 749. Report under Council Decision 1999/296/EC for a monitoring mechanism of Community greenhouse gas emissions

Annex 5.4. *The list of main laws on energy sector and environment protection in the Republic of Moldova*

– Law on environment protection no. 1515-XII of 16.06.91993
– Law on natural resources no. 1102-XIII of 2.02.1997
– Law on production and household waste no. 1347-XIII of 9.10,1997
– Law on regime of produce and regime of harmful substances no. 1236-XIII of 3.07.1997
– Law on secondary material resources no. 787-XIII of 23.03.1996
– Law on ecological expertise and evaluation of impact on environment no 581-XIII of 29.05.1996
– Law on urbanism principles and territory arrangement no. 835-XIII of 17.05.1996
– Law on air protection no. 1422-XIII of 17.12.1997
– Law on hydrometeorological activity no. 1536-XIII of 25.02.1998
– Law on licensing certain activities no. 332-XIV of 26.03.1999
– Law on payment for environment pollution no. 1540-XIII of 25.02.1998
– Law on atmospheric air protection no. 1422-XIII of 17.12.1997
– Law on population sanitary-epidemiological assurance no. 1513-XII of 16.06.1993
– Law on consumer rights protection (1993)
– National Strategy for Sustainable Development: Moldova XXI.
– The First National Communication of the Republic of Moldova under the UN Framework Convention on Climate Change.
– Energy Strategy of the Republic of Moldova until 2010 approved by the Government Resolution no. 360 of 11.04.2000.
– Law on energy sector no. 1525-XIII of 19.02.1998.
– Law on electrical energy no. 137-XIV of 17.09.1998
– Law on natural gases, no. 136-XIV of 17.09.1998
– Law on energy conservation, no. 1136-XIV of 13.07.2000
– Government Resolution no. 1092 of 31.10.2000: On usage of renewable energy resources
– Law on the oil products market, no. 461-XV of 30.07.2001
– Law on transportation through international pipelines, no. 592-XIII of 26.09.1995
– Law on the concept of energy enterprises privatization, no. 63-XIV of 25.06.1998
– Law on individual project for restructuring the electrical power enterprises, no. 223-XIV of 23.12.1998
– Law on restructuring the debts of the electrical power enterprises, no. 336-XIV of 01.04.1999
– Law on protection of competition, no. 1103-XIV of 2000

– Energy program of the Republic of Moldova for the period 1995-2005, worked out within the TACIS Project EMO92-010 in 1995

– Energy program of the Republic of Moldova for 1995-2005, worked out in 1995 by the Institute of Energy of the Academy of Science of Moldova

– On reorganization and privatization of the gas complex, Parliament Resolution no. 1556-XIV of 26.02.1998

– Restructuring plan of the thermal power sector in the Republic of Moldova, Government Resolution no. 581 of 21.06.1999

– Planning at minimal costs for the State Enterprise (SE) "Moldelectrica": The Reform project of electrical power market in the Republic of Moldova. Paper elaborated by the CMS Energy (USA) on the request USAID, Contract no. OUT-EEU-I-OO-99-00018-00, Task paper no. 801, 2001

– Action plan of the central and local public authorities with regard to usage of renewable energy resources. Government Resolution no. 1092 of 31.10.2000

– Plan of actions on reaching the objectives on social-economic development and 2001 Budget Law execution, Government Resolution no. 239 of 2.04.2001

– Gas supply program of the Republic of Moldova until 2005. Government Resolution no. 123 of 19.12.2001.

Annex 5.5. *Requirements integration on environment protection. ìThe Concept of Environment Protection in the Republic of Moldova (2001)î*

1) in industrial sector:

a) promotion of ecologically pure production, by applying non-polluting technology;

b) raising the interest of enterprises in diminishing the waste volume, in processing and re-using thereof as secondary raw material;

c) modernization and exploitation of harmful substances collection, that proceed from technological processes;

d) allocation of funds, collected as pollution tax, with the purpose to provide the costs pertaining to urgent actions on environment protection;

2) in energy sector:

a) attraction of investments for rehabilitation of electrical and thermal power plants with the purpose to increase their efficiency and reduce negative impact on the environment;

b) elaboration of a national strategy on thermal energy supply for consumers, setting a way to combine the centralized heating systems with the autonomous sources;

c) elaboration of a mechanism on raising the interest of the consumers in energy conservation;

d) elaboration of standards on preventing the environment pollution by reducing emissions and gradual substitution of coal and oil products, in the energy sector and road-transport, with liquefied and compressed natural gases;

e) elaboration of a national concept on producing energy from non-traditional sources and implementation of an increasing usage of renewable energy sources, including by attraction of foreign investments;

f) carrying out a comprehensive and detailed inventory of the impact on the environment, proceeding from the production and usage of energy;

g) improving the mechanisms of tax reduction of tax exemption for the investments used in energy conservation;

3) in agriculture and food industry

a) implementation of the national Concept on ecological agriculture, production and sale of food products non-modified ecologically and genetically;

b) practicing organic agriculture;

c) undertaking measures on prevention and fighting soil erosion, land-sliding and other forms of soil degradation;

4) in transports and communications sector:

reduction of environment pollution by all kinds of transport, including road-transport in the urban localities, by optimizing the transport scheme, creation of diagnosis stations on pollution with exhaust gases, banning the import of vehicles with a high degree of pollution, control of fuel quality;

5) in the military sector:

a) elaboration of a concept on ecological security in the National Army;

b) carrying out studies on evaluation of the military objects impact on the environment;

c) ecological education and training of the military;

d) elaboration of a program on implementation of military ecological management;

6) in the field of socio-human ecology:

a) elaboration and implementation of a national program on eco-socio-human situation and meeting the vital needs of the humans;

b) organization of an integrated monitoring of eco-socio-human indicators;

c) elaboration of a complex action program in the field of formation of ecological awareness among the employed population;

7) in the field of health care:

a) implementation of the National Action Plan for health care related to environment;

b) reaching the cooperation agreement between the environmental central authorities and health care ones;

8) in territory arrangement and constructions:

a) working out a national action plan for territory arrangement to include national ecological network as main component of the environment components;

b) working out certain concepts on sustainable development of localities, on national architecture, on certain model plans for territory organization at both county and local levels, in compliance with bio-geographical, geological and climate zonification of the country territory;

c) exploitation of reserves of construction materials by observing ecological requirements;

9) in the field of housing and communal facilities:

a) application of construction technologies with reduced impact on environment and usage of ecologically pure construction materials;

b) raising efficiency of energy consumption in the process of construction and housing maintenance;

c) localities sanitation, including separate collection of domestic waste;

d) projection and placement of controlled dumps, by determining the amount of urban waste;

10) in the field of informational and training systems, of public information:

a) extending the range of activities of the Environment Informational Center;

b) creation of county ecological informational centers;

c) improving the study programs with regard to ecological law and environment management in the educational institutions;

d) creation of a data basis on environment quality and state of natural resources;

e) collaboration with mass-media and active involvement of ecological NGOs;

11) in the field of R&D in the field of environment:

a) deepening scientific researches in priority problems of environment, continuation of researches on economic activities on environment;

b) extending the range of researches on climate change, deserting, ozone layer conservation and bio-diversity;

c) supplying laboratories with up-to-date equipment;

d) intensifying international cooperation in the field of R&D.

PROJECT PROPOSALS

MEDIUM-SIZED PROJECT CONCEPT PAPER

1. Project name:	**2. Proposed GEF Implementing Agency:**
Increasing the Production Capacity of ELIRI Joint-Stock Company by Modifying the Assembly Line, to Produce CFL type Compact Fluorescent Lamps for Efficient Energy Savings.	*United Nations Development Program (UNDP)*
3. Country or countries in which the project is being implemented: *Republic of Moldova*	**4. Country eligibility:** *The Republic of Moldova ratified the UNFCCC in 1995. It is eligible under a financial mechanism of the UNFCCC*
5. GEF focal area(s): *Climate Change: OP 5 "Removing barriers to energy conservation and energy efficiency".*	**6. Operational program/Short-term measure:** *This proposal would fall under the short-term response measure of GEF's Operational Strategy and under the long-term operational program on efficient consumption.*

7. Project linkage to national priorities, action plans, and programs:

As a part of actions to prepare the first national communication to FCCC, the Government of the Republic of Moldova is exploring these strategies that simultaneously are beneficial for the local and global environments. Project will tackle the Climate Change priorities of Moldova proceeding from the Resolution of the Government of the Republic of Moldova No. 1216 of November 29, 2000. ìSupplying the budgetary organizations with compact fluorescent lampsî for energy savings and the Program of Action of the National Agency for Energy Conservation (ANCE). Increasing nationwide expansion of efficient lighting in public buildings, saving energy resources, and rational utilization of energy are the most important priorities. The project will help reduce oil import fated to energy-producing industries, reduce emissions from public electricity generation and benefit the global environment. The Government has announced a decision to countenance over the next seven years the manufacture and sale of fluorescent lamps for energy savings in order to replace more than 142 thousand lamps in institutional and administrative sectors. As the energy saving is obviously expected, in the next 20 years about 1,8 million of the electronic filament lamps will be replaced, which are used primarily in the lighting systems in public and private buildings. Until 2020 this activity will turn over in the reducing by at least 20% the energy use of the lighting systems all over the country and will save an estimated 250 GWh per year or 465 Gg of CO_2 *emissions per year.*

8. Status of national operational focal point review (dates):

Submitted: 06 April, 2001 *Acknowledged: 18 April, 2001* *Endorsed: 19 April, 2001*

9. Project rationale and objectives:

The Government of the Republic of Moldova is willing to develop strategies with mutual benefit for local and global environment. The most important priorities are increasing of energy efficient consumption, saving energy resources, rational utilisation of energy. In concordance with Governmentís decision it is promoting production of high-energy efficient compact fluorescent lamps of CFL type, in order to replace the current electronic filament lamps. Itís important that manufacturing of compact fluorescent lamps are in great demand in Moldova and will have a large utilization. According the Resolution of Government of the Republic of Moldova No. 1216 of November 29, 2000 ìSupplying the budgetary organizations with compact fluorescent lampsî, the Ministry of Industry and Energy has organized an auditing committee consisted of representatives of the Ministries interested to secure during 2001-2007 period 142,365 CFL type compact fluorescent lamps instead of electronic filament lamps. The committee organized a tender for the best proposes of supplying the institutional and administrative sectors with CFL type lamps. The tender was won by the Joint-Stock Company ELIRI that is the single factory in the Republic of Moldova, which produce CFL type lamps. This company offered the most convenient conditions for the operation of replacement of electronic filament lamps. At present the Joint-Stock Company ELIRI produces two components for CFL type compact fluorescent lamps with a long span running, 10 times more than of electronic filament lamps ñ 10 thousand hours for the non-integrated compact fluorescent lamp (as a rule they are imported from EU countries) and 20 thousand hours for electronic starting-regulating device AE. The current CFL type compact fluorescent lamps production is of 5,000 pieces per year. ELIRI intends to increase the production in order to honor the Government order.

These kinds of lamps are intended for use as illumination sources instead of electronic filament lamps. Electronic starting-regulating device AE is intended for conversion of alternating current circuit voltage of 220V/50Hz to supply non-integrated compact fluorescent lamp with power of 10, 13, and 18W. Device AE provides instantaneous ignition of CFL and it works without twinkle that is characteristic for traditional fluorescent lamps with electromagnetic starting-regulating mechanism. By using devise AE it is easy to change non-integrated CFL of one color to the lamp or other color or to change lamp when it is burnt out. CFL type lamps are adapted to the Moldovan condition of electric network tension instability.

Through GEF assistance it is expected to implement new technologies and increase the manufactory capacity of CFL type lamps. As the energy production in Moldova depends on the imported oil these will be significant benefits from the reduction of expenses for oil import and the great reduction of emissions from electricity generation will be reached.

10. Expected outcomes:

As a result of the extra investments made in the assembly line and in manufacturing processes, ELIRI expects to complete the project activities in 1.5 years and to turn out during this period 50,000 CFL type lamp.

Subsequently ELIRI plans to increase production to 50,000 units per year.

It is estimated that in a six year period the replacement of 142 thousand electronic filament lamps with CFL type lamps only in budgetary organizations and institutional buildings in order to increase the energy efficient consumption will save an estimated 115 GWh (19.3 GWh per year during a six-year period). For this condition, the reduction of CO_2 *emissions is equal to 214,000 tons (36,000 tons per year).*

It is expected that in the next 20 years about 1,8 million of the electronic filament lamps will be replaced, that are used primarily in the lighting systems for both public and private buildings. Until 2020 this activity will turn over in the reducing by at least 20% the energy use of the lighting systems all over the country and will save an estimated 250 GWh per year or 465 Gg of CO_2 *emissions per year.*

As the energy saving as it is obviously expected, the projectís implemented activities will serve as public awareness building around the identification of the energy savings potential in public and private buildings in the lighting systems.

11. Planned activities to achieve outcomes:

ELIRI will conclude a subcontract agreement with TOPAZ Joint-Stock Company. TOPAZ produces plastic carcass and plated circuit that are used for electronic starting-regulating device AE (electronic adapter) of the CFL type lamps. This agreement will include the manufacture of the electronic starting-regulating device AE of CFL type lamps. GEF will support the in-country costs (incurred in foreign exchange) of ELIRI-TOPAZ joint venture agreement. The switchover of the assembly line to CFL type lamps will be complete in a half a year, after that ELIRI intends to increase the manufacture on the announced level of production (50,000 CFL type lamps per year). The main priorities are:

a) Preparing the necessary framework for successful concluding of the project development:

1. *concluding the technological documentation of the project;*
2. *projection and manufacturing of the non-standard equipment and instruments;*
3. *Organization of the production sector;*
4. *Acquisition of the additional equipment:*
   - Semiautomatic pick and place system SMD (Type PRECIPLACER PP-2003) - 1;
   - Manual pick and place system SMS (Type SMS-100 TF) ñ 2;
   - Dispenser (Type PPS ñ 100E) ñ2;
   - IR-reflow oven (Type SM 500 CXE) ñ 1;
   - Soldering station (Type MVT 201 AE) ñ 3;
   - The Complete SMD Assembly and Rework (Type TF 700) ñ 1;
   - Conductive Rework/Repair (Type PRC 200) ñ1;
   - Visual Control System (Type LYNX) ñ 1;
   - Component Level Fault Locator (Type PEL 780) ñ 1;
   - Digital Storage Oscilloscope (Type TDS 714 L) ñ 1;
   - Dell Dual Pentium III-933 MHz ñ1;
   - Dell Dimension 4100+3 ComV90.56K/modem ñ 5;

b) Installation and assembling of the necessary equipment;

c) Manufacturing of Electronic Starting-Regulating Device AE for Energy Saving Compact Fluorescent Lamps;

d) Public awareness building (organization of workshops with participation of relevant stakeholders and population) regarding the links between the Climate Change and the long-term operational programs on removing barriers to energy conservation and energy efficiency;
12. Stakeholders involved in project: *TOPAZ Joint-Stock Company*
13. Information on project proposer: The Electric Installations Research Institute (ELIRI) was established in 1959. The institute is specialized in radio-electronics and instrument production. ELIRI Institute was reorganized into a Joint-Stock Company in 1995 and now runs profitably as a commercial organization. It has equipment for development and delivery of cast microwires and production on base these microwires, have installations for production of hybrid microcircuits and other measurement and electric installations. ELIRI has experimental production sector with welding, metalworking, bench working, stamping equipment. Its developed devices and components with high metrology characteristics are used in different domains of science and technology. The institute has experience in organizing output of series production at the plants of Moldova, Russia, the Ukraine, Byelorussia, Romania and South Korea. The ELIRI has obtained more than 500 certificates of authorship for its inventions, many of which have been patented in the USA, Great Britain, Japan, Germany and Italy.
14. Information on proposed executing agency (if different from above): Same as above.
15. Estimated budget (in US$ or local currency): ***GEF:*** $350,000 ***ELIRI (Co-financing):*** *$75,000* ***Other donors (Co-financing):*** *$275,000* ***TOTAL:*** *$700,000*

MEDIUM-SIZED PROJECT CONCEPT PAPER

1. Project name: *Increasing the CO2 Sequestration Capacity by Afforestation of Prut and Reut Rivers Basins Protection Zones and of Degraded Land Plots Impracticable for Agriculture in the Central and Southern Regions of the Republic of Moldova.*	***2. GEF Implementing Agency:*** *UNDP Moldova*
3. Country or countries in which the project is being implemented: *Republic of Moldova*	***4. Country eligibility:*** *The Republic of Moldova ratified the UNFCCC in 1995. It is eligible under a financial mechanism of the UNFCCC.*
5. GEF focal area(s), and/or cross-cutting issues: *Multifocal: Integrated Ecosystem Management.*	***6. Operational program/Short-term measure:*** *This proposal would fall under the short-term response measure of GEF's Operational Strategy. Experience gained under this project would also help develop GEF's long-term operational program on Integrated Ecosystem Management (OP 12).*
7. Project linkage to national priorities, action plans, and programs: *The Government of the Republic of Moldova is exploring those strategies that simultaneously benefit the local and global environments. Project will tackle the Biodiversity and Climate Change priorities of Moldova deriving from:* *- Convention on Biodiversity, ratified by Republic of Moldova on May 16, 1995;* *- National Environment Action Plan - NEAP (1995);* *- "Strategy for Sustainable Development of the Forest Sector of the Republic of Moldova" (2000);* *- Law No. 140-XII on April 27, 1995 "On the protection of rivers and water basin zones";* *- Law No. 1041-XIV on June 15, 2000 "On soil amelioration by afforestation of degraded soil areas";*	

- Resolution of the Government of the Republic of Moldova No. 595 of October 29, 1996 "On improving the management of forest sector and protection of forest vegetation".

- Resolution of the Government of the Republic of Moldova No. 32 dated January 16, 2001 "On measures of stabilization of protection zones and riverside bands of the rivers and water basins";

- Resolution of the Government of the Republic of Moldova No. 107 dated February 7, 2001 "On executing of the Resolution of the Government of the Republic of Moldova No. 595 dated October 29, 1996 and some supplementary measures for optimization of the management of forest sector and protection of forest vegetation".

The proposed project is consistent with the guidelines of the recent Conference of the Parties of the Convention on Biological Diversity. It has been identified as a priority afforestation for the Republic of Moldova by the National Environment Action Plan (1995) and will address the priorities of the National Biodiversity Strategy and Action Plan of the Republic of Moldova.

The extension of the forest territory for amelioration of the ecological condition and for enhancing the GHG emissions sequestration is an important component of the ecological policy of the state. The project will contribute to conservation of the regional significant biodiversity of the forests and wetlands, to increasing carbon sequestration, reducing national GHG emissions and benefit the global environment.

8. Status of national operational focal point review (dates):

Submitted: April 06, 2001 Acknowledged: April 18, 2001 Endorsed: April 19, 2001

9. Project rationale and objectives:

The Government of the Republic of Moldova develops strategies with mutual benefit for local and global environment. One of the most important priorities is conservation of the globally significant biodiversity of the Republic of Moldova by measures of afforestation.

According to:

- the Convention on Biodiversity, ratified by Republic of Moldova on May 16, 1995;

- the "Strategy for Sustainable Development of the Forest Sector of the Republic of Moldova"(2000),

- law No. 140-XII on April 27, 1995 "On the protection of rivers and water basin zones",

- the Resolution of the Government of the Republic of Moldova No. 595 of October 29, 1996 "On improving the management of forest sector and protection of forest vegetation",

- the Resolution of the Government of the Republic of Moldova No. 32 dated January 16, 2001 "On measures of stabilization of protection zones and riverside bands of the rivers and water basins",

- the resolution of the Government of the Republic of Moldova No. 107 dated February 7, 2001 "On executing of the Resolution of the Government of the Republic of Moldova No. 595 of October 29, 1996 and some supplementary measures for optimization of the management of forest sector and protection of forest vegetation",

- law No. 1041-XIV of June 15, 2000 "On soils amelioration by afforestation of degraded soil plots".

The overall objective of the project is to provide a comprehensive framework to manage natural systems across sectors and administrative boundaries within the context of sustainable development. It has to provide opportunities to address issues related to the conservation and sustainable use of biodiversity, land degradation, management of water bodies and stabilization of atmospheric GHG through a programmatic approach.

The project would strengthen the forests and wetland protection and management through building capacity of the main stakeholders and providing infrastructure support. The project would also build local support for biodiversity conservation through afforestation of a ration of water basins protection zones and for degraded soils that impracticable for agriculture through implementation of a public awareness program.

The regional partnership for the Prut basin management could be established. This area is becoming important for regional cooperation and environmental protection of Danube basin zone. The joint implementation of the project with Romania should have great positive contribution for regional environment protection under Biodiversity and Climate Change Conventions.

As the forest distribution in the Republic of Moldova is uniform: the forest cover degree in the Southern region is of 6,7% and in the Central region - of 13.1% of the total forests, these afforestation will be of significant benefits for national environment by increasing the CO_2 sequestration level. Planting of new (1800 ha) forest zones will lead to an extra CO_2 sequestration of 10800 tons per year.

Through GEF assistance is expected for:

- building local support for forest and wetland conservation by afforestation measures,

- planting new forest vegetation areas and enhancing the areas covered with meadow vegetation,

- increasing the sequestration capacity of GHG emissions,

- equilibrating the hydrological regime of the Reut and Prut rivers,

Improving the soil quality in the Southern and Central regions of the Republic of Moldova: Taraclia County, Cahul County, Orhei County and Gagauz Ery Autonomous Region.

10. Expected outcomes:

As a result of project implementation it is expected that local government and non-government institutions would be strengthened in afforestation management planning and local communities would participate in forest and wetland conservation and management. The financial sustainability of the afforestation and conservation activities would ensure benefits from forests and wetlands conservation and would be secured by local communities; the collaboration on biodiversity conservation with neighborhood countries Romania and Ukraine should be improved; the CO_2 sequestration capacity would increase up to 10800 tons per year.

It is estimated that in a two years period the afforestation of 1800 ha will also establish new and beneficial conditions for national environment.

The enhancement of areas covered with forest vegetation, meadow and wetland vegetation will contribute to:

- sequestrating extra CO_2 emissions;

- reducing the processes of soil erosion;

- creating new ecosystems with positive impact on soil productivity in the Southern and Central regions of the country;

- reducing the muddiness and degradation of aquatic basins of the Reut and Prut rivers;

- reducing the water pollution of the basin of Prut river - which is an important trans-border zone;

- constituting an ecological connection network between the forest sectors within the river's protected zones.

It is expected that the project activities will serve as public awareness building around the identification of the GHG emissions storage potential at the national level.

11. Planned activities to achieve outcomes:

- Baseline studies (biodiversity and afforestation activities survey, emphasis on the necessary data base required for management policies and activities, socio-economic assessment, threat assessment) and zoning:

1. Specification of the degraded agricultural land plots intended to be afforested within the water basins protection zones and in the Southern and Central regions of the country: Taraclia County, Cahul County, Orhei County and Gagauz Ery Autonomy Region;

2. Preparing the soil for the afforestation;

3. Establishing the soil limiting factors for forest vegetation by chemical analyzing of the respective soil profiles;

4. Concluding the map-drawing and technological documentation of the project;

5. Using the native forest species assortment for the intended afforestation measures and qualitative and quantitative estimation of the reproduction material:

Oak tree species (Quercus pubensis, Quercus robur);
Willow tree species (Salix alba, Salix fragilis);
Poplar tree species (Populus alba, Populus nigra);
Maple tree species (Acer platanoides, Acer campestris);
Elm tree species (Ulmus scabra, Ulmus laevis);
Hornbeam (Carpinus betulus);
Linden species (Tilia cordata, Tilia argintea);
Ash tree (Fraxinus excelsa).

6. Institutional needs assessment and providing the basic infrastructure for biodiversity conservation and afforestation activities management (clearing up of the estate relationship of the intended to be afforested degraded agricultural land plots);

7. Afforestation of 500 ha of the degraded agricultural land plots in the Southern region of the country: Taraclia County, Cahul County and Gagauz Ery Autonomy Region;

8. Afforestation of 500 ha of the degraded agricultural land plots in the Central region of the country - Orhei County;

9. Afforestation of 800 ha within the Prut and Reut rivers protected zones;

10. The enclosing of the afforested areas;

11. Capacity building (training, exchange programs, provide equipment) of major stakeholders responsible for biodiversity conservation management and afforestation activities, establishment of the monitoring framework of the new planted zones in order to assure sustainability of outputs;

- To enhance the co-operation between the civil society, the Local Public Authorities and the State Forest Service towards the sustainable forest management;

- Public awareness building (organization of workshops with participation of relevant stakeholders and population from the zones involved in the project development) regarding the links between the Climate Change and afforestation activities;

- Strengthening of state priorities concerning CO2 sequestration.

12. Stakeholders involved in project:

Government organizations:

- State Forest Service;

- Ministry of Ecology, Construction and Territorial Development;

- Ministry of Agriculture and Processing Industry;

- "Apele Moldovei" Republican Concern.

Local public authorities:

- Taraclia County Council;

- Cahul County Council;

- Orhei County Council;

- Gagauz Ery Autonomy Region Supreme Assembly;

Non-governmental organizations:

- Ecological Movement of the Republic of Moldova (MEM);

- Territorial Farmers Associations;

13. Information on project proposer:

***The State Forest Service** is the central authority in the forestry sector and is under Government subordination. The State Forest Service promotes the state policy and applies the Strategy for Sustainable Development of the Forest sector of the Republic of Moldova. The State Forest Service is responsible for the protection, conservation and the development of the Forestry Fund. It also organizes the capitalization and utilization of the forest products in order to supply needs of the national economy with timber, other products and services. One of the activity objects of this organization is the forest management on the ecological principles in order to improve the environment. Although, at present, the State Forest Service is a state organization, it operates based on self-financing and financial autonomy. The international partners of the State Forest Service are The Romanian National Administration of the Forests, Russian Federal Forest Service and FAO. During the last three years the State Forest Service was involved in two international projects. The first project "The elaboration of the Strategy for Sustainable Development of the Forest Sector of the Republic of Moldova" (1998-1999) was supported financially by the Ministry of Environment of the Finland Republic and by the Service of Forests and Parks of this country. The budget of the project was 2,3 million FM. The second project "The elaboration of the urgent program of action for protection against diseases and pests, including defoliator pests of the forests in the Republic of Moldova" (August 1999 - October 2000), had a budget of $ US 315,000 and was supported by FAO.*

***The Ecological Movement** of the Republic of Moldova (MEM) is a non-governmental, non-profit, apolitical organization. It was established on November 15, 1990, has 17 territorial organizations and another 15 affiliated organizations. The organization is the largest NGO and counts 11,000 active members. The Ecological Movement of the Republic of Moldova promotes the rehabilitation of the natural equilibrium, recovery of the environment and of population, formation of an ecological vision of the citizens. The main objectives of the Ecological Movement of the Republic of Moldova are:*

- Awareness and sensitizing of the public opinion to the environment problems;

- Participation in creation of a flexible system of ecological education, concerning with Climate Change problems;

- Conservation of the biological diversity and extension of the protected areas;

- Implication of the public in the expertise of the projects and economical activities and in the implementation of the concept of sustainable development.

- Participation in the process of elaboration of the ecological legislation;

- Harmonization of the national ecological legislation with global ecological standards; and *- Promotion of ratification of the International Environmental Conventions.* *During last three years the Ecological Movement of the Republic of Moldova has promoted 10 projects and was involved in an International project "Terra Moldaviae", supported financially by the World Bank, UNDP Moldova and Soros Foundation.*
14. Information on proposed executing agency (if different from above): *The Ecological Movement.*
15. Estimated budget (in US$): ***GEF:*** *$ US 475,000;* ***Government of the Republic of Moldova:*** *$ US 50,000 (according the Resolution of the Government of the Republic of Moldova No. 32 of January 16, 2001 "On the measures of stabilization of protection zones and riverside bands of the rivers and water basins");* ***State Forest Service:*** *$ US 10,000;* ***Local Public Authorities:*** *$ US 15,000;* ***Other donors:*** *$ US 400,000;* ***TOTAL:*** *$ US 950,000*

BLOCK A PDF

PART I ñ ELIGIBILITY	
1. Project name: *Endowing Ialoveni Landfill with CH4 Emissions Recuperation Equipment, to Reduce Methane Emissions Proceeded from Landfill.*	***2. Proposed GEF Implementing Agency:*** *Programul Na¸iunilor Unite pentru Dezvoltare (PNUD)*
3. Country or countries in which the project is being implemented: *Republica Moldova*	***4. Country eligibility:*** *The Republic of Moldova ratified the UNFCCC in 1995. It is eligible under a financial mechanism of the UNFCCC.*
5. GEF focal area(s): Climate change *OP 6 "Promoting the adoption of renewable energy by removing barriers and reducing implementation costs".*	***6. Operational program/Short-term measure:*** *This proposal would fall under the short-term response measure of GEF's Operational Strategy (OP. 6: Promoting the adoption of renewable energy by removing barriers and reducing implementation costs). Experience gained under this project would also help the development of landfills in other localities and reduce GHG emissions.*
7. Project linkage to national priorities, action plans, and programs: *The Project will tackle the Climate Change priorities of Moldova deriving from the National Environment Action Plan - NEAP (1995), National Program for Waste Utilization (2000), the Resolution of Government of the Republic of Moldova No. 1092 of October 31, 2000 "On utilization of the renewable energy resources" and the latest Governmental Action Plan (1999-2002) that stipulates promotion of Efficient Environmental Policy, which has as objectives rational utilization of natural recourses, waste minimization, separated collection and waste utilization as alternative resources of energy. As a part of activities to prepare the first national communication to FCCC, the Government of the Republic of Moldova was exploring those strategies that simultaneously benefit the local and global environments. The project will contribute to improving air quality, reducing methane emissions proceeded from landfill exploration and benefit the global environment.*	
8. GEF national operational focal point and date of country endorsement: *Ministry of Ecology, Construction and Territorial Development of the Republic of Moldova - April 19, 2001.*	
9. Project rationale and objectives: *Government of the Republic of Moldova is willing to develop strategies with mutual benefit for local and global environment. The most important priorities are rational utilization of natural recourses, waste minimization, separated collection and waste utilization as alternative resources of energy. In the Republic of Moldova, municipalities have established their own companies for waste collection and management. There are also some private companies*	

for waste collection operating on the contract basis in the municipalities. The municipalities, usually finance from the environmental funds landfill construction and maintenance.

In concordance with the Government's Resolution of the Republic of Moldova No. 606 of June 28, 2000 "National Program for Waste Utilization" and the Resolution of Government of the Republic of Moldova No. 1092 dated October 31, 2000 "On utilization of the renewable energy resources" the Ministry of Ecology, Construction and Territory Development pre-selected the Ialoveni Mayoralty to start negotiations with IPROCOM Project Institute to supply the Ialoveni town landfill with CH_4 recuperation equipment. This pre-selection was caused by the fact that Ialoveni is one of the most important suburbs of the capital city where the population thereof (about 20,000 inhabitants) is not supplied with an adequate catering of communal solid waste collecting. The populations of another two big villages (about 18,000 inhabitants) is interested in the services of this landfill and are going to pay the necessary charges for waste removal and landfill use. Another reason was the fact that the authorities are interested to exclude the pollution danger of the water resources since the old landfill which belongs to Ialoveni municipality is situated under the extra price of water which provide the capital of the country - Chisinau. The Ialoveni town Mayoralty plans to reorganize the mentioned landfill in order to reduce the CH_4 emissions and exclude the danger of pollution. Recuperated CH_4 emissions will serve as alternative energy resource to cover the energy necessities for landfills maintaining.

Implementation of the pilot project in Ialoveni town for landfill of waste will serve as an example for other municipalities and mayoralties to promote sustainable community-based management of waste and to provide the enabling conditions for CH_4 emissions reduction. There are 40 towns that could use such experience in the Republic of Moldova.

10. Expected outcomes:

The implementation of the project will support development of the National Program for Waste Utilization, which stipulates creation of new landfill equipped with CH_4 emissions recuperation units in each county.

As a result of the implementation of the project, Ialoveni town Mayoralty expects to ensure the adequate waste management, which will serve as a model of landfill construction and maintenance. A considerable reduction is expected of CH_4 emissions from Ialoveni Landfill, which being recuperated, will provide the energy necessities for landfill maintaining.

The experience gained during the implementation of this project could be used throughout the country in order to obtain a significant reduction of CH_4 emissions from landfill.

11. Planned activities to achieve outcomes:

Ialoveni town Mayoralty represented by the Communal Husbandry Enterprise will conclude an agreement with IPROCOM Project Institute. IPROCOM Project Institute will perform the technical project documentation and the Communal Husbandry Enterprise will perform the engineering works. This works will conclude into a landfill endowed with CH_4 emissions recuperation equipment.

The main priorities are:

- *Survey with reference to the concrete conditions of the Ialoveni Landfill and elaboration of the documentation for feasibility study on the technical and financial assessment of building of the Ialoveni Landfill and the efficiency of the embedded investments (the preliminary estimated project cost is $ US 110,000, the preliminary share of co-financing is of $ US 10,000 - Ialoveni Mayoralty);*
- *Adaptation of the landfill project-model for elaborated by the IPROCOM Project Institute to landfill build for CH_4 reduction and provision with heat and electrical power of the Landfill administrative block and possible, of the consumers of Ialoveni town;*
- *Bottom arrangement and its waterproof;*
- *Administrative blocks building;*
- *Acquisition of the additional equipment;*
- *Installation and assembling of the necessary networks of CH_4 captive installation and other gas pipes, as well as of the pump station and of the gas holder for storing the recovered CH_4 emissions;*
- *Connecting of the local consumers and the nearest heat generation station to alternative source of energy - recovered methane gas;*
- *Organization of two workshops on discussing the results of the project and directions of Solid Waste Disposal on Land Systems and possibilities to use waste as renewable energy sources and to reduce the GHG emissions.*

The switchover of the works will be complete in 1,5 years.

12. Stakeholders involved in project: *Ialoveni town Mayoralty;* *Ialoveni Communal Husbandry Enterprise;* *IPROCOM Project Institute;* *The Ministry of Ecology, Construction and Territory Development of the Republic of Moldova.*
PART II ñ INFORMATION ON BLOK A PDF ACTIVITIES
13. Activities to be financed by the PDF: *(a) Organization of two workshops and training seminars with the Government representatives, Mayoralty staff, specialists from waste sector and consumer representatives of Ialoveni town to discuss terms of reference for a consumer survey and a pre-investment feasibility study, as well as the results of the project and the directions of further development of the waste management, utilization of renewable energy sources and the reduction of GHG emissions;* *(b) Pre-investment feasibility study to gauge the demand for technical and financial assistance and desired features of the Ialoveni Landfill equipped with CH_4 emissions recuperation units:* *- Survey with reference to the concrete conditions of the Ialoveni Landfill and elaboration of the feasibility study documentation on the technical and financial assessment of the building of the Ialoveni Landfill and the efficiency of the embedded investments;* *- Elaboration of the pilot project on utilization of Ialoveni Landfill equipped with CH_4 emissions recuperation units for CH_4 reduction and provision with heat and electrical power of the landfill administrative block and consumers of the Ialoveni town;* *- Acquisition of the additional equipment;* *- Installation of the necessary networks of the gas pipes, of the pump station, of the gas holder for storing the recovered CH_4 emissions;* *- Connecting of the local consumers and the nearest heat generation station to alternative source of energy - recovered methane gas;* *- Organization of two workshops on discussing the results of the project and directions of Solid Waste Disposal on Land Systems and possibilities to use waste as renewable energy sources and to reduce the GHG emissions.*
14. Expected outputs and completion dates: *a) Terms of reference (to be completed in two months);* *b) Measures and analysis of CH_4 emissions (to be completed in four months);* *c) Tabulation and analysis of technical, financial and environmental assessment (to be completed in six months).*
15. Other possible contributors/donors and amounts: *National Ecological Found - $ US 1,000 for workshop;* *Local Budget of Ialoveni Mayoralty - $US 1,000 for workshop.*
16. Total budget and information on how costs will be met (including the Block A grant): ***Workshop** - $ US 2,000 (Co-financing);* ***Feasibility study** - $ US 13,000 (GEF)* ***TOTAL:** $ US 15,000*
PART III ñ INFORMATION ON THE APPLICANT INSTITUTION

17. Name: *Ministry of Ecology, Construction and Territorial Development.*	***18. Date of establishment, membership, and leadership:*** *Tugui T., Main Specialist, General Division on the Pollution Prevention and Environmental Improvement, Ministry of Ecology, Construction and Territorial Development.*
19. Mandate/terms of reference: *The Department for Environmental Protection was established in 1988, and was reorganized in 1998 as a Ministry of Environment and in 2001 as a Ministry of Ecology, Construction and Territorial Development.*	*20. Sources of revenue:* *The Ministry of Ecology, Construction and Territorial Development is a budgetary organization and its latest annual budget was of $ US 78,000.*

The General Division on the Pollution Prevention and Environmental Improvement has the following obligations: *- To elaborate Environmental Pollution Prevention Strategy;* *- To elaborate air, water and soil protection and waste management laws;* *- To promote Prevention Pollution Policy;* *- To promote the international cooperation in the area of waste management.*	
21. Recent activities/programs, in particular those relevant to the GEF: *General Division on the Pollution Prevention and Environmental Improvement is involved in the project "Preparatory Approximation Work of the Republic of Moldova in Integrated Pollution Control and Waste Management" supported financially by TACIS.*	
PART IV ñ INFORMATION TO BE COMPLETED BY IMPLEMENTING AGENCY	
22. Project identification number:	
23. Implementing Agency contact person:	
24. Project linkage to Implementing Agency program(s):	

BLOCK A PDF

PART I ñ ELIGIBILITY	
1. Project name: *Reduction of Methane Emissions from Communal Sewage Sludge by Reorganization of the Baltsi Scrubbing Plant into an Anaerobic Treatment Plant for Communal Biological Wastes and Sludge.*	***2. Proposed GEF Implementing Agency:*** *United Nations Development Program (UNDP).*
3. Country or countries in which the project is being implemented: *Republica Moldova*	***4. Country eligibility:*** *The Republic of Moldova ratified the UNFCCC in 1995. It is eligible under a financial mechanism of the UNFCCC.*
5. GEF focal area(s): Climate Change *OP. 6 "Promoting the adoption of renewable energy by removing barriers and reducing implementation costs".*	***6. Operational program/Short-term measure:*** *This proposal would fall under the short-term response measure of GEF's Operational Strategy. Experience gained under this project would also help the development of biogas plants for treatment of organic wastes in other localities and reduce GHG emissions.*
7. Project linkage to national priorities, action plans, and programs: *The Project will tackle the CC priorities of Moldova deriving from the National Environment Action Plan - NEAP (1995), the Strategy of Sustainable Development of the Communal Systems for Water and Sewage Supplying of the Republic of Moldova (1999), National Program for Waste Utilization (2000), the Governmental Action Plan (1999-2002) and the Resolution of the Government of the Republic of Moldova No. 1092 dated October 31, 2000 "On utilization of the renewable energy resources". These documents stipulate the promotion of an efficient environmental policy, which has as objectives rational utilization of natural recourses, waste minimization, sustainable development of the communal sewage and waste water systems. The main priorities of these programs are: thorough repairs of the communal systems and re-equipment of the scrubbing plants in order to reduce GHG emissions and use the organic waste and sludge as alternative resources of energy. The Government of the Republic of Moldova is exploring strategies that simultaneously benefit the local and global environments. The project will contribute to improving the global environment by reducing GHG emissions proceeded from communal sewage sludge.*	
8. GEF national operational focal point and date of country endorsement: *Ministry of Ecology, Construction and Territorial Development - April 19, 2001*	

9. Project rationale and objectives:

Government of the Republic of Moldova started development of the strategies with mutual benefit for local and global environment. Among the most important priorities is reduction of GHG emissions proceeded from wastewater handling under anaerobic conditions. In concordance with the Strategy of Sustainable Development of the Water and Sewage Communal Systems (1999), the National Program for Waste Utilization (2000) and the Resolution of the Government of the Republic of Moldova No. 1092 dated October 31, 2000 "On utilization of the renewable energy resources", action are promoted focused on the usage of alternative energy resources and implementation of new technologies directed on use of renewable energy resources.

The proposed project is expected to provide execution of the works for fulfilling of the feasibility study on reorganization of a scrubbing plant into a biogas plant for municipal wastewater treatment in order to provide anaerobic processes in enclosed systems where CH_4 is recovered and utilized.

Being supported by the Ministry of Ecology, Construction and Territorial Development the Baltsi Mayoralty represented by "Apa-Canal" Baltsi, which is an organization responsible for water and sewage communal systems, has started negotiations with "Intexnauka" J.S.C. to reorganize the Baltsi Scrubbing Plant into a Biogas Plant for Municipal Wastewater Treatment. The Baltsi Mayoralty would like to use this opportunity to reorganize the Baltsi Scrubbing Plant in order to reduce the CH_4 emissions and exclude the anaerobic processes on the sludge fields and into deep lagoon treatment systems which provide anaerobic environment and significant methane production.

Based on the preliminary estimation it is expected to reorganize the Baltsi Scrubbing Plant into an Anaerobic Treatment Plant for Communal Biological Waste and Sludge on the base of the existent equipment - two methane tankers with a total capacity of 3200 m^3, which are out of order at the moment.

Implementation of the pilot project will serve as a model for other municipalities, to promote sustainable community management of waste. It will provide the enabling conditions for CH_4 emissions reduction, reduce the water pollution, muddiness, degradation of aquatic basin of the Reut river which crosses the city and will provide the supply with heat and electricity from renewable energy sources.

10. Expected outcomes:

As a result of the investments made for this project it is expected to complete the activities in two years and to fulfil during this period:

- *To elaborate a survey on the technical and financial assessment of the reorganizing of the Baltsi Scrubbing Plant into an Anaerobic Treatment Plant for Communal Biological Wastes and Sludge including cost benefit analyzing (the preliminary estimated project cost is $ US 1,780,000);*
- *To elaborate the pilot project on utilization of the anaerobic treatment plants for communal biological wastes for CH_4 emissions and COD reduction (13,450 m^3 biogas production by day), production of heat and electrical power (on the base of a small power plant station with a rated power capacity of: electricity 1,2 MW and heat 1,300 kW) and saving of fossil energy resources (corresponds to 1,5 Gg fuel oil by year);*
- *Strengthening the institutional and management capacities of the waste generated sector;*
- *To elaborate the recommendation on the production and broad usage in the Republic of Moldova of the anaerobic treatment plants for communal biological wastes and organic wastes and sludge, that will allow to save a significant amount of fossil energy resources and reduce the GHG emissions.*

11. Planned activities to achieve outcomes:

The Baltsi Mayoralty represented by "Apa - Canal" Baltsi will conclude an agreement with "Intexnauka" J.S.C. Intexnauka will perform the project documentation and engineering works. The works will conclude into an anaerobic treatment plant for communal biological wastes and sludge endowed with an enclosed system where CH_4 is recovered and utilized for the production of heat and electrical power. The main priorities are:

- *Survey with reference to the concrete conditions of the Baltsi Scrubbing Plant and elaboration of the feasibility study on the technical and financial assessment of the reorganizing of the Baltsi Scrubbing Plant into an Anaerobic Treatment Plant for Communal Biological Wastes and Sludge and the efficiency of the embedded investments;*
- *Elaboration of the pilot project on utilization of Anaerobic Treatment Plants for Communal Biological Wastes and Sludge for CH_4 and CBO reduction and provision with heat and electrical power of the plant and of the consumers of those localities where scrubbing plants exist;*

- *Rehabilitation of two methane tankers, which are out of order, with a total capacity of 3,200 m^3 and building of new two methane tankers with the same total capacity of 3,200 m^3;*
- *Acquisition of additional equipment for preparing organic substrates of waste for anaerobic treatment (classifier, mechanical installations for mixing - grinding mills etc.);*
- *Acquisition and installation of gas equipment (gas-holder, gas compressors, etc);*
- *Acquisition of centrifuges for dehydration of sludge and organic substrates;*
- *Acquisition of equipment for briquettation of the dry precipitant sludge with fuel part of the solid municipal wastes;*
- *Acquisition of the gas-holder of the gasification of fuel briquettes;*
- *Installation of the necessary networks of the sludge and gas pipes and of the pump stations;*
- *Building on the base of the local heat generation station of a small power plant station with a power capacity of: electricity 1,2 MW and heat 1,300 kW;*
- *Co-generation of heat and electrical power on the base of the small power plant station and saving of fossil energy resources;*
- *Utilization of the treated digested sludge in agriculture;*
- *Organization of two workshops on discussing the results of the project and directions of Wastewater Systems and possibilities to use waste as renewable energy sources and to reduce the GHG emissions.*

12. Stakeholders involved in project:

Baltsi Mayoralty,
"Intexnauca"J.S.C.,
"Apa-Canal" Balti,
Ministry of Ecology, Construction and Territorial Development.

PART II ñ INFORMATION ON BLOK A PDF ACTIVITIES

13. Activities to be financed by the PDF:

(a) Organization of two workshops and training seminars with the Government representatives, Mayoralty staff, waste generated sectors specialists and consumer representatives of Baltsi city to discuss terms of reference for a consumer survey and a pre-investment feasibility study, as well as the results of the project and the directions of further development in the field of waste management, the renewable energy sources utilization and on the reduction of GHG emissions;

(b) Pre-investment feasibility study to gauge the demand for technical and financial assistance and technical features of the Biogas Plant for Treatment of Organic Wastes and Sludge:

- *Survey with reference to the concrete conditions of the Baltsi Scrubbing Plant and elaboration of the feasibility study on the technical and financial assessment of the reorganizing of the Baltsi Scrubbing Plant into an Anaerobic Treatment Plant for Communal Biological Wastes and Sludge including cost-benefit analysis;*
- *Elaboration of the pilot project on utilization of Anaerobic Treatment Plants for Communal Biological Wastes and Sludge for CH4 and CBO reduction and provision with heat and electrical power of the plant and of the consumers of localities where there are scrubbing plants;*
- *Rehabilitation of the out of order two methane tankers with a total capacity of 3,200 m^3 and building of new two methane tankers with the same total capacity of 3,200 m^3;*
- *Acquisition of additional equipment for preparing organic substrates of waste to anaerobic treatment (classifier, mechanical installations for mixing - grinding mills etc.);*
- *Acquisition and installation of gas equipment (gas-holder, gas compressors, etc);*
- *Acquisition of centrifuges for dehydration of sludge and organic substrates;*
- *Acquisition of equipment for briquettation of the dry precipitant sludge with fuel part of the solid municipal waste;*
- *Acquisition of the gas-holder of the gasification of fuel briquettes;*
- *Installation of necessary networks of sludge and gas pipes and of pump stations;*
- *Building on the base of the local heat generation station of a small power plant station with a power capacity of: electricity 1,2 MW and heat 1,300 kW;*
- *Co-generation of heat and electrical power on the base of the small power plant station and saving of fossil energy resources;*

- Utilization of the treated digested sludge in agriculture; - Organization of two workshops on discussing the results of the project and directions of Wastewater Systems and possibilities to use waste as renewable energy sources and to reduce the GHG emissions.
14. Expected outputs and completion dates: *a) Terms of reference (to be completed in two months);* *b) Measures and analysis of CH_4 emissions (to be completed in four months);* *c) Tabulation and analysis of consumer survey (to be completed in six months).*
15. Other possible contributors/donors and amounts: *Baltsi Mayoralty US $ 1,000 for 2 workshops.*
16. Total budget and information on how costs will be met (including the Block A grant): ***Workshop** - $US 1,000 (Co-financing)* ***Feasibility study** - $US 19,000 (GEF)* ***TOTAL:** $ US 20,000*

PART III ñ INFORMATION ON THE APPLICANT INSTITUTION

17. Name: *The Mi nistry of Ecology, Construction and Territorial Development, 9 Cosmonautilor St., office 632, MD 2005, Chisinau, Republic of Moldova.* *"Intexnauca" J.S.C., 64 V. Alexandri St., MD 2012, Chisinau, Republic of Moldova*	***18. Date of establishment, membership, and leadership:*** *Guvir T., Head of the Division Prevention Pollution of the General Division on the Pollution Prevention and Environmental Improvement, Ministry of Ecology, Construction and Territorial Development, tel. (3732) 226851, E-mail: guvir@mediu.moldova.md.* *Totoc Gheorghii, Manager of the "Intexnauca" J.S.C, tel. (3732) 270320, fax 93732) 221615, E-mail: intex@ch.moldpac.md*
19. Mandate/terms of reference: *The Department of the Environmental Protection was established in 1988, it was reorganized in 1998 as a Ministry of Environment and in 2001 as a Ministry of Ecology, Construction and Territorial Development.* *The General Division on the Pollution Prevention and Environmental Improvement has the following obligations:* *- To elaborate Environmental Pollution Prevention Strategy;* *- To elaborate air, water and soil protection and waste management laws;* *- To promote Prevention Pollution Policy;* *- To promote the international cooperation in the area of waste management.*	***20. Sources of revenue:*** *The Ministry of Ecology, Construction and Territorial Development is a budgetary organization.*

21. Recent activities/programs, in particular those relevant to the GEF: *General Division on the Pollution Prevention and Environmental Improvement is involved in the project "Preparatory Approximation Work of the Republic of Moldova in Integrated Pollution Control and Waste Management" supported financially by TACIS.*

PART IV ñ INFORMATION TO BE COMPLETED BY IMPLEMENTING AGENCY

22. Project identification number:
23. Implementing Agency contact person
24. Project linkage to Implementing Agency program(s):

Block A PDF

Part I ñ Eligibility	
1. Project name: *Utilization of Solar Energy and Wind Power as Alternative Sources of Energy, to Supply Taraclia town of the Taraclia County in the Southern Region of the Republic of Moldova with Electricity and Hot Water.*	***2. Proposed GEF Implementing Agency:*** *United Nations Development Program (UNDP)*
3. Country or countries in which the project is being implemented: *Republic of Moldova.*	***4. Country eligibility:*** *The Republic of Moldova ratified the UNFCCC in 1995. Eligible under a financial mechanism of the UNFCCC.*
5. GEF focal area(s): *Climate Change: OP 6 "Promoting the adoption of renewable energy by removing barriers and reducing implementation costs".*	***6. Operational program/Short-term measure:*** *This proposal would fall under the short-term response measure of GEF's Operational Strategy, the long-term operational program on promoting the adoption of renewable energy by removing barriers and reducing the long term costs of low GHG emitting energy technologies. Experience gained under this project would also contribute to building local energy networks, enhancing the nation-wide expansion of renewable energy sources for using in electricity and heat generation for rural communities and reducing GHG emissions from energy sector.*

7. Project linkage to national priorities, action plans, and programs:

The Government of the Republic of Moldova is exploring the strategies that simultaneously benefit the local and global environments. Project will tackle the Climate Change priorities of Moldova following from the Program of Action of the National Agency for Energy Conservation (2000), the Government's Program of Action (2000 - 2002) and the Resolution of Government of the Republic of Moldova No. 1092 dated October 31, 2000 "On utilization of the renewable energy resources". The Supreme Commission of Experts for Science of the Republic of Moldova and the Presidium of the Academy of Science of the Republic of Moldova supports these programs of action.

The project will contribute to reducing the oil import for the energy-producing industries, the GHG emissions from public electricity generation and benefit the global environment.

Promotion of projects like this can contribute to building local energy networks, which assures a certain independence of energy supplying system and will contribute to reduction of GHG emissions from energy sector.

Increasing nation-wide expansion of renewable energy sources for using in electricity and heat generation for rural communities should also contribute to poverty alleviation and sustainable development.

8. GEF national operational focal point and date of country endorsement:

Ministry of Ecology, Construction and Territorial Development of the Republic of Moldova - April 19, 2001.

9. Project rationale and objectives:

Government of the Republic of Moldova started development of the strategies with mutual benefit for local and global environment. The most important priorities are rational utilization of energy, saving energy resources, increasing of energy efficient consumption and expansion of renewable energy using in electricity and heat generation for rural communities' development. According to the Action Program of the National Agency for Energy Conservation (ANCE), the Government's Program of Action (2000 - 2002) and the Resolution of Government of the Republic of Moldova No. 1092 dated October 31, 2000 "On utilization of the renewable energy resources" activities are promoted that are focused on the usage of alternative energy resources and implementation of new technologies fated to energy saving and energy efficient consumption.

The proposed project is expected to provide execution of the works for creating of the alternative local energetic complexes for supplying with heat and electric energy the small and medium sized localities of the Republic of Moldova.

In conditions of the Republic of Moldova the solar energy reception is characterized with the possibility of obtaining about 0,1 - 0,15 kWh from each square meter of solar collector. The potential value of energy, gained from 1 m2 of the solar water heating installation will be 150 - 190 kWh per year. The utilization of solar collectors with a total area of 1500 m2 will allow to save energy equal to that from the utilization of almost 350 thousand tons of conventional fuel per year. The reduction of —Œ2 emissions is equal to nearly 700 Gg per year.

There are large possibilities of using the wind energy in the Republic of Moldova, where the average wind velocity per annum is 2,5 - 4,5 m/s (in some regions the average wind velocity reaches 6 - 8 m/sec). The production of electricity from the wind power generation units could reach nearly 1200 - 2000 kWh from 1kW wind power units per year. The installation of wind power units with a total power of 0,5 MW which is equal to production of electricity on the level of 600-1000 MW per year will allow to save energy amount resulting from the utilization of almost 1290 - 2150 thousand tons of conventional fuel per year. The reduction of —Œ2 emissions is equal to 1800 - 3000 Gg per year.

By the proposed project it is expected to create the complex of wind power generation units and of the solar water heating installations in Taraclia town, which is a component part of the Taraclia Free Economical Zone, in order to supply the Taraclia's consumers with alternative energy resources. The pre-selection of this town is explained by the following reasons: the economical arguments are important (the local and foreign companies which activate in Taraclia Free Economical Zone are interested in co-financing of such kind of projects), the average amount of solar days per year in Taraclia County is of 200-220, the wind velocities typical to Taraclia is of 4-5 m/s.

Through the GEF assistance it is expected to enhance the regulatory support for renewable energy, to implement new technologies and increase the usage of renewable energy resources (solar and wind energy). As the energy production in Moldova depends on the imported oil, the significant benefits from the reduction of expenses for oil import and the great reduction of emissions from electricity generation will be reached.

10. Expected outcomes:

As a result of the investments made for this project it is expected to complete the activities in three years and to fulfil during this period:

- *Elaboration of the feasibility study on the technical and financial assessment of the using of solar and wind power installation and efficiency of the embedded investments (the preliminary estimated project cost is $ US 675,000, the preliminary share of co-financing is of $ US 125,000 - Enterprises of the Free economical Zone of the Taraclia town);*
- *Elaboration of the pilot project on utilization of wind power installation for complex provision with heat and electric energy of consumers of certain localities characterized by the presence of an average year wind velocities of 4-5 m/s;*
- *Installation of the solar water heating equipment with a total area of heating collectors of 1500 m2;*
- *Installation of the wind power units with a total power of 0,5 ÃW;*
- *Strengthening the institutional and management capacities of the energy sector;*
- *Recommendation on production and broad using in the Republic of Moldova of the solar and wind power installations that will allow to save significant amount of organic fuel and greatly reduce GHG emissions, that is of important benefit for the Republic of Moldova.*

11. Planned activities to achieve outcomes:

The Research Technical Design Center of Energy "“ehInformEnergo" Ltd possesses technologies of utilization renewable energy resources. It concluded a joint venture agreement with some of the enterprises from the Free Economical Zone of the Taraclia town assigned by the Mayoralty of Taraclia to organize the manufacture of solar collectors and wind power units. The switchover of the assembly lines to solar water equipment and wind power units will be completed in two years. GEF will support a part of the in-country costs (incurred in foreign exchange) of the "TehInformEnergo" and the enterprises from the Free Economical Zone of the Taraclia town joint venture agreement. The main priorities are:

- *Survey with reference to the concrete conditions of Taraclia town and technical recommendations for local network creation. Elaboration of the feasibility study on the technical and financial assessment of the using of solar and wind power installation and efficiency of the embedded investments;*
- *Elaboration of the pilot project on utilization of wind power installation for complex provision with heat and electric energy of consumers of certain localities characterized by the presence of an average year wind velocities of 4-5 m/s;*
- *Documentation of the experimental solar and wind power installation;*
- *Manufacturing and installation of the solar collectors and wind power units for providing with heat and electric energy the Taraclia town consumers;*
- *Organization of workshops and training seminars with specialists on discussing the results of the project and directions of the further development of the renewable energy sources utilization and on the reduction of GHG emissions.*

12. Stakeholders involved in project:

- *The Research Technical Design Center of Energy "TehInformEnergo" Ltd;*
- *Taraclia town Mayoralty;*
- *The Enterprises of the Free Economical Zone of the Taraclia town;*
- *Institute "EnergoProiect" of the Ministry of the Industry and Energy of the Republic of Moldova;*
- *The Faculty of Energy of the Technical University of the Republic of Moldova.*

PART II - INFORMATION ON BLOCK A PDF ACTIVITIES
13. Activities to be financed by the PDF: *a) Organization of two workshops and training seminars with government, energy industries, specialists and consumer representatives of Taraclia County to discuss terms of reference for a consumer survey and a pre-investment feasibility study, as well as the results of the project and the directions of further development in the field of the renewable energy sources utilization and on the reduction of GHG emissions;* *b) Pre-investment feasibility study to gauge the demand for technical and financial assistance and desired features of the solar heat collectors and wind power units:* *- Execution of the technical documentation of the solar and wind power installations;* *- Elaboration of the pilot project on utilization of wind power installations for provision with heat and electric energy of consumers from localities characterized by the presence of an average year wind velocities of 4-5 m/s;* *- Recommendation on production and broad using in the Republic of Moldova of the solar and wind power installations that will save significant amount of organic fuel and considerably reduce the GHG emissions, that is of important benefit for the Republic of Moldova.*
14. Expected outputs and completion dates: *a) Terms of Reference (to be completed in two months); and* *b) Tabulation and analysis of consumer survey (to be completed in six months).*
15. Other possible contributors/donors and amounts: *Taraclia Mayoralty US $ 1,000 for workshop.*
16. Total budget and information on how costs will be met (including the Block A grant): *Workshop - $US 1,000 (Co-financing)* *Consumer survey - $US 19,000 (GEF)* *TOTAL: US $ 20,000*

PART III - INFORMATION ON THE APPLICANT INSTITUTION	
17. Name: *The Research Technical Design Center of Energy "TehInformEnergo" Ltd.*	***18. Date of establishment, membership, and leadership:*** *The Research Technical Design Center of Energy "TehInformEnergo" Ltd. was created in 1993. It has a stuff of 15 members. Mr. Postolatii V. held the post of the Executive Manager of the Center.*
19. Mandate/terms of reference: *The Research Technical Design Center of Energy "“ehInformEnergo" Ltd. performs researches and works on its own themes and based on joint venture agreements. The themes of studies cover the broad spectrum of problems on energy, including the use of the renewable sources of energy. The Center supports the broad international relationships with countries from the Europe, Asia and America.*	***20. Sources of revenue:*** *The last budget of the Research Technical Design Center of Energy "“ehInformEnergo" Ltd. reached the level of MDL 110,000 (1 US $ = 12.8 MDL).*
21. Recent activities/programs, in particular those relevant to the GEF: *The collaborators of the Center execute some of the activities undertaken by the Government and the Ministry of Industry and Energy, participated in Climate Change Project, executed some international projects focused on the energy saving activities and in some projects supported by TACIS and by Fichtner. The Center is also the performer of some national programs in the field of energy and took part in preparing some of the Government Resolutions, Laws and other Normative Acts concerning the energy sector.*	

PART IV - INFORMATION TO BE COMPLETED BY IMPLEMENTING AGENCY
22. Project identification number:
23. Implementing Agency contact person:
24. Project linkage to Implementing Agency program(s):

ABBREVIATIONS

AC — Annual Costs
AG — Air generator
AS — Local Autonomous Systems for Heat Supply
ASM — Academy of Sciences of the Republic of Moldova
BBP — Back-to-back Electrical Power Station
BLS — Base Line Scenario
CHP — Combined Heat and Power Plant
DTC — Discounted Total Cost
d.s. — Dry Substance
EDN — Electric Distribution Net
EN — Electrical Network
ENPEP — Energy and Power Evaluation Program (software)
GDP — Gross Domestic Product
GHG — Greenhouse Gases
GSTI — Gas-Steam Turbine Installation
GTI — Gas Turbine Installation
GWP — Global Warming Potential
HAS — High Alternative Scenario
HEP — Hydro-electric Plant
HP — Heat Pump
HWB — Hot Water Boiler
IAAE — International Agency for Atomic Energy
IMS — Inter-Medium Scenario
IPCC — Inter-governmental Panel for Climate Change
LCS — Large Centralized Systems for Heat Supply
LNG — Liquefied Natural Gases
LoCS — Local Centralized Systems for Heat Supply
LPG — Liquefied Petroleum Gases
MAED — Model for Analysis of the Energy Demand (software)
MDL — Moldovan Lei
MSW — Municipal Solid Wastes
MTPP — Moldovan Thermal Power Plant
NARE — National Agency for Energy Regulation
NPP — Nuclear Power Plant
NPV — Net Present Value
OEL — Overhead Electric Line
PEX — Type of plastic
PV — Photovoltaic
RES — Renewable Energy Sources
SF — Sugar Factories
ST — Steam Turbine
STI — Steam Turbine Installation
TMH — Total Mano-metric Height
TN — Thermal Networks
TP — Thermal Plant
TPP — Thermal Power Plant
UCTE — Union for Coordination of Electricity Transportation (Union pour la Coordination du Transport de líElectricite)
UNFCCC — United Nation Framework for Climate Change Convention
WASP — Wien Automatic System Planning (software)
WEP — Wind Energy Plant

NOTATION

C_{ex} — Average annual operation and maintenance costs
C_W — Net cost of energy produced by a wind station
D_r — Rotor diameter
H_o — Height of the tower
K_u — Utilization coefficient of nominal power of an air-generator
W_a — Discounted volume of energy produced during the life-time of power plant

CHEMICAL SYMBOLS

CH_4 — Methane
CO — Carbon Monoxide
CO_2 — Carbon Dioxide
NMVOC — Non-Methane Volatile Organic Compound
CFCs — Chlorofluorocarbons
CF_4 — Carbon tetrafluoride
HFC — Hydrofluorocarbons
H_2S — Sulfured Hydrogen
NH_3 — Ammonium
N_2O — Nitrous Oxide
NO_x — Nitrogen Oxides
PFC — Perfluorocarbons
R12 — Refrigerating agent
SF_6 — Sulfur hexafluoride
SO_2 — Sulfur Dioxide

UNITS OF MEASURE

Unit of measure for pressure

bar — Bar
Pa — Pascal
kPa — Kilo Pascal, 1kPa = 10^3 Pa
MPa — Mega Pascal, 1 MPa = 10^6 Pa

Unit of measure for energy

Cal — Calorie, 1 cal = 4,186 Joule
kcal — Kilo calories, 1 kcal = 4186 Joule
Gcal — Gigacalorie, 1 Gcal = 10^9 cal = 1.163 MWh
J — Joul, 1 J = 0,239 cal
kJ — Kilojoule, 1 kJ = 10^3 Joule
GJ — Gigajoule, 1 GJ = 10^9 J = 0.278 MWh
TJ — Terajoule, 1 TJ = 10^{12} Joule
PJ — Petajoul, 1PJ = 10^{15} Joule
W — Watt ñ unit of demand of capacity
Wh — Watt-hour, 1 Wh = 860 calories
kWh — Kilowatt or„, 1 kWh = 860 kcal
MW — Megawatt, 1 MW = 10^6 W t.c.c.
MWh — Megawatt or„, 1 MWh = 0.86 Gcal = 0.123 t.c.c.
MWe — Megawatt electric - unit of measure for energetics
GWh — Gigawatt hour, 1 GWh = 10^9 Wh = 860 Gcal
TWh — Terawatt hour, 1 TWh = 10^{12} Wh
g.c.e. — Grams of coal equivalent. 1 g.c.e. = 8.14 Wh
kg c.e. — Kilograms of coal equivalent. 1 kg.c.e. = 8.14 kWh
t.c.e. — Tons of coal equivalent. 1t.c.c. = 8.14 MWh = 7000 Gcal

Unit of measure for weight

kg — Kilogram, 1 kg = 1,000 grams
Mg — Megagram, 1 Mg = 1 ton„ = 10^6 grams
Gg — Gigagram, 1 Gg = 1,000 t = 10^9 grams
Tg — Teragram, 1 Tg = 1,000,000 t = 10^{12} grams
t — Ton, 1 t = 1Mg = 1,000 kg
t.n.f. — Tons of natural fuel
kt — Kilotonne, 1 kt = 1,000 tonne = 1 Gg

Unit of measure for a volume

l — Liter
m^3 — Cubic meter, 1 m^3 = 1,000,000 cm^3
Nm^3 — Normal cubic meter

Unit of measure for concentration

ppmv — parts per million of volume - unit of measure for concentration