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SUSTAINABLE ENERGY ACTION PLAN OF KAUNAS DISTRICT MUNICIPALITY

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Kaunas 2012

SUMMARY OF THE SUSTAINABLE ENERGY ACTION PLAN OF KAUNAS DISTRICT MUNICIPALITY

Action Plan will be a management tool for Kaunas District municipality to provide the sustainable development of Kaunas District social and economic environment, increase of life quality of Kaunas District residents by use of the available resources.

Kaunas District takes up 2.29% of Lithuania's territory. Kaunas District has area of 1496 km^2 of which 4.2% are cities, 2.3% - industrial and roads, 54.9% - farmlands, 31% - forests, 5.2% bodies of water, 2.4% are other areas. Kaunas District is one of the most agricultural districts in Kaunas County, 90% of Kaunas District's plots are agricultural, forestry or aqua cultural (77.1% agricultural plots, 12.3% forestry plots, 0.6% aquaculture plots). Arable land takes up 72.4% of the agricultural land, 24.2% by pastures and 3% by gardens and berry plantations. About 68% of the crop consists of grain crops, 9.29% of perennial grasses, and 7.87% of rapeseed.

Main industry branches are agricultural and wood products processing, cattle and animal slaughtering, peat industry, meat and milk processing, manufacturing of wooden packaging and furniture, production of building materials, manufacturing and maintenance of farming machinery, logistics. Other developed industries are sand clay mining, peat mining and fabrication, production of building materials, milk and other food product processing, fabrication of knitwear, clothing industry, manufacturing of farming equipment and tractors. Kaunas Free Economic Zone is located 7 km from the city of Kaunas, in Kaunas District, occupying 1000 ha and holds a lot of potential for different industries and logistics.

Most of the natural gas is consumed by industrials, utility household customers and people. "Kauno Energija" is the main provider of heating and steam in the district of Kaunas. Heating sources are usually placed near settlements and serve their inhabitants. Main type of fuel is natural gas. Oil is the second most used. Besides these two, peat and sawdust are used. Peat is very important source of energy for Kaunas district because it is a local one. During 1998–2002, the decentralization of heating supply in villages and the reconstruction of heating supply systems in cities occurred, they enabled the elimination of inefficient heating supplies, waive the use of coal and heating oils. Despite the developed heating supply systems in the region, the demand is a lot less then the technical capabilities of production.

Municipal waste landfills remain the main means of waste treatment. A regional waste treatment system and center are developed in Kaunas District; they are responsible for

the closing of landfills and further treatment of waste. Most of the landfills have been rehabilitated; only one landfill is still operating and is located in Lapės.

Only one utility waste recycling facility is operating in Kaunas District – Ltd. "Super Montes". This facility has three waste recycling and processing lines. They are specialized for glass waste, mixed packaging waste and mixed utility waste. Bulky wood and electronic fractions, tires and building scraps are sorted in the first assorting chamber. Primary 50-100 mm fractions for biofuel are extracted, later these fractions are grinded down to 1-50 mm fractions. This kind of fuel is suitable for cogeneration boilers, cement plants and other consumers.

The plan has analyzed the use of natural gas, electricity and heating in Kaunas's District economy: food industry, energy, farming, community amenities and people households. In the period analyzed, the use of gases fluctuated slightly from 24.8 mln. m^3 (2008) to 28.5 mln. m^3 (2006). Consumption of gas decrease by 7% in 2009, compared to 2005. Most quantity of gas in Kaunas district are used in energy plants (31.7–36.2 %) and private households (28.7–42.3 %).

Electricity usage increased by about 18.7% in the four year period of 2005–2009 – from
155 GWh in 2005 to 184 GWh in 2009. More than 90% of electricity is consumed by households (44.2–52.6%) and public service sectors (41–46.6%).

It is clear that the consumption of electricity is steadily rising. It is due to the rise of the housing market in Kaunas District. Electricity consumption in public services rose slightly from
72.4 GWh (2005) to 75.6 GWh. It is safe to say, that this is due to the economic development of the country, because in 2008 86.5 GWh of electricity was consumed.

Heating supply is centralized in twelve areas of residence in Kaunas district. 9 of which are operated by Plc. "Kauno energija", the other 3 by Utility Center Ltd. that is owned by Kaunas District municipality. Centralized heating is supplied in these areas of residence:

Supply of gas is organized by company "Lietuvos dujos" Kaunas branch. In the territory analyzed, Girionys, Ežerėlis, Babtai and Vilkija don't have natural gas network. The remainder of the territory has a natural gas supply system that is enough for individual heating by natural gas. Heating of premises and water by using natural gas, play a big role in supplying individual boilers with ecological fuel in the analyzed areas.

Kaunas District has 10 district and 1 Vilkija apartment community boilers, their total combined power is about 152 MW. Heating was supplied to 336 buildings in 2010, that consist of 5237 apartments and their heating area is about 297600 m^2.

Kaunas District's boilers produced and realized 77.9 GWh of heating energy in 2010. Most of it was produced by using natural gas. However 4 of the boilers used biofuel, one of them – biogases. The power of heat generating devices, using renewable energy sources, was 18.1 MW in 2010.

It is expected the decrease of centralized heating supply from 7 250 toe (2010) to 6 920 toe (2020). Demand of electricity should grow from 17 230 toe (2010) to 23 230 toe (2020). Decentralized consumers households and service sector consumption of energy for heating premises should increase from 16 100 toe (2010) to 17 390 toe (2020), while heating of water will see an increase from 2 790 toe (2010) to 3080 toe (2020). Preliminary assessment of Kaunas District energy consumption demand, tells us that in 2020 energy demand will reach 63 310 toe.

Kaunas District has a reasonable amount of experience in developing renewable energy technologies in public and business sectors. Due to the lack of planning and coordination, renewable energy was being developed spontaneously in individual governmental, academic and business parties.

There are several actions planned for energy saving and reduction of CO_2 emissions:

Reduction of energy consumption in buildings;

Promoting renewable energy sources;

Energy saving in public and manufacturing sectors.

Activity of reduction of energy consumption in buildings includes modernization of municipality buildings, renovation of apartment houses, renovation and modernization of public buildings, modernization of space heating systems. It is planned that in 2020 will be achieved reduction of energy consumption about 21 GWh and it will reduce CO_2 emissions by more than 3000 t per year.

Implementation of Renewable energy sources in Kaunas District will generate about 115 GWh electrical and heat energy and will reduce CO_2 emissions by more than 15000 t per year. It is planned implementation of Biomass, Wind, Solar and Geothermal plants and installations for electricity and heat generation. Moreover Municipality of Kaunas District has planned activities of dissemination of best practices in Renewable Energy sector and education of personnel of public institutions.

Energy saving in public and manufacturing sectors includes activities related with application of economical lighting systems in municipality buildings, modernization and renovation outside lighting of territories and streets, electricity saving in private sector, industry and agriculture. These activities can reduce energy consumption by 11 MWh per year and mitigate CO_2 emissions by 2100 t.

All planned actions of energy saving and implementation of Renewable energy will reduce energy consumption by 147 GWh in the year of 2020 (28 % lower than in 2008) and will reduce CO_2 emissions by 20440 t per year (25 % lower than in 2008).

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INTRODUCTION

The growth of energy demand in the world and to its production related air pollution poses a clear threat of climate change and unpredictable changes. According to carbon dioxide (CO2) emissions (which is one of the main sources of greenhouse gas emissions) EU is in third place in the world (3900 million tons). Behind is only China (more than 6000 million tons) and the United States (about 5800 million tons).

The main source of CO_2 emission is energy production which produces the two times greater pollution than the transport. International Environmental Agency (IEA) predicts that without measures to reduce emissions over the next 40 years alone power installations will increase CO2 emissions by more than 60 %.

Increased use of renewable energy sources (RES) is a one of the most important instruments that reduce greenhouse gas emissions in the atmosphere as much as met the United Nations Framework Convention on Climate Change Kyoto Protocol and other Community and international obligations after 2012.

This is an important factor for energy supply security, development of technologies and innovations, providing employment and regional development, particularly in rural and remote areas. RES in the transport's fuel produce is one of the most effective means by which the Community can reduce its transportation sector's dependence on oil imports and influence to the transport fuel market.

It is recognized that innovations and sustainable competitive energy policy can stimulate economic growth. Production of energy from renewable sources often depends on local or regional small and medium-sized enterprises (SMEs). Importance of emerging growth and employment opportunities in Member States and their regions which happens due to the regional and local investments in energy production from renewable resources. Therefore, Member States should support national and regional development of these areas; promote local and regional development initiatives; changes on renewable energy-related best practices and promote the use of the Structural Funds.

Main feature of RES based energy is an integrated system. Current stage of its development in Lithuania is an innovation and present or future business benefit of the system is not exactly known. There are currently carried out feasibility studies on the opportunities of RES uses; search of optimal use of RES technologies; implementation of pilot projects. Some of them have already been completed that the results are under monitoring and analysis.

There is a significant potential to reduce greenhouse gas emissions using agricultural waste, such as: manure, slurry and other animal and organic waste for biogas production. It

also can have a significant benefit for the environment in producing heat and electricity, and biofuels. Due to the decentralized nature and the regional investment structure, biogas plants can have a decisive influence on the sustainable development and open up new opportunities for farmers to earn income from the [European Parliament and Council Directive 2009/28/EC].

Special attention can be given to sectors that disproportionately suffer because of technological advances and economies of scale and therefore remain under-developed, but which in the future could contribute more to the implementation of the 2020 target. Starting point for indicative trajectory should be 2005. Because it is the last year for which reliable data on national renewable energy are available.

Member States may encourage regional and local authorities to set targets in excess of national targets and to involve regional and local authorities in the national renewable energy action plan process and in awareness of the benefits of renewable energy education campaign.

Community and the Member States should seek to reduce the overall energy consumption and to increase energy efficiency in the transport sector.

The principal means of reducing the amount of energy consumed in the transport sector includes public transport planning, support for public transport, increasing output of electric cars and production energy-efficient, smaller size and lower engine capacity cars. To obtain an energy model, which would encourage the use of renewable energy, it is necessary that Member States, as well as the regions and local authorities to cooperate in strategic areas.

Member States shall encourage all stakeholders, in particular local and regional administrative bodies on planning, designing, building and renovating industrial or residential areas to ensure installation equipment and systems for the production of electricity, heating and cooling from renewable energy resources. The same must be done in district's heating and cooling system. Where appropriate, Member States shall, in particular, encourage local and regional administrative bodies to include heating and cooling from renewable energy sources in the planning of city infrastructure.

The Member States with the participation of local and regional authorities, shall develop suitable information, awareness-raising, guidance or training programs in order to inform citizens on renewable energy development and use of practical feasibility and benefits.

1. PURPOSE AND OBJECTIVES

The main purpose of Sustainable Energy Action Plan of Kaunas District - implementation of the sustainable development of social and economic policy in Kaunas District, improvement of the quality of life for residents saving energy and introducing renewable energy sources.

To achieve this goal these challenges are raised:

- reduce final energy consumption in 2020, at least 20%;
- reach the usage of renewable energy sources in the energy balance by the year 2020 at least 20%;
- educe CO_2 emissions by at least 20%.

Results of the Action Plan are compared with the 2008 indicators (baseline year).

Preparing Sustainable Energy Action plan analysis of energy consumption in the area is carried out, potential and the experience of Kaunas district in renewable energy presented, measures for reducing energy consumption in buildings, public sector and manufacturing, installing and promoting renewable energy sources provided, self-analysis of the Sustainable Energy Action Plan implemented.

2. CURRENT SITUATION AND FUTURE VISION

2.1 Information about Kaunas District

Kaunas District is situated in the Southern part of Lithuanian central lowland where Suvalkija, Aukštaitija and Žemaitija lands converge, merges our countries beigest rivers - the Nemunas, the Neris and Nevėžis. Kaunas District covers 2.29% of the Republic of Lithuania. Among all 60 municipalities in Lithuania Kaunas District municipality is number 14 from the occupied area and the seven most populous. Total Kaunas District area is 1496 km^2, of which 4.2% are towns and villages, 2.3% - the industry, roads, and 54.9%-agricultural land, 31% - forests, 5.2% - waters 2.4% - other areas.

Fig. 2.1 Position of Kaunas District in the map

Kaunas district is one of the most densely populated in the country. The average population density (56.9 persons in km^2) Kaunas region is 1.1 times higher than the density of the population of the Republic of Lithuania. Local Government framework law (adopted in 1990 February 12) granted Kaunas district municipality status (Kaunas district municipality http://LTL.wikipedia.org/wiki/Kauno_rajono_-savaldyb % C4% 97). The municipality has three cities, 10 small towns and 370 villages.

Fig 2.2 Elderships in Kaunas District Municipality

Kaunas district also stands out from the other in abundance of scientific institutions. There are situated a number of higher education schools from Kaunas city, Aleksandro Stulginskio University, Kaunas Forestry and Environmental Engineering College, Lithuanian Forest Research Institute, Lithuanian Institute of Horticulture. As a district does not have a significant administrative center, which could operate in the vast majority of the district education offices, such abundance of education institutions is a distinctive feature. Large potential of scientific development influences the development of human resource Kaunas District.

2.2 Capacity of production and energy infrastructure of Kaunas District

Agricultural land occupies more than half of the region's territory (53%), intensively are used meadows and pastures. Kaunas District is one of the most agricultural area in county, because 90% of land consists of agricultural, forestry and aquaculture land plots (77.1% agricultural land; 12.3% forestry purposes; 0.6% aquaculture). This area can be divided so: arable land 72.4%; meadows and natural pastures 24.2%; orchards and berry plantations – 3%. Grain crops are the main cropwhich is grown in District (68%) other are perennial

grasses – 9.29%, rape crops – 7.87% [Kaunas District Municipalitie's master plan, NPR, 2007].

The District is very diverse in industries. The main industrial activities of Kaunas District are agricultural and wood product processing, livestock and animal slaughter, the peat industry, meat and milk processing, furniture, wooden container production, manufacture of building materials, farm machinery sales and service logistics. There are also development of such industry as - sand and clay extraction, peat extraction and production of building materials, milk and other food processing, manufacture of hosiery, clothing, apparel, agricultural machines and tractors. Many of these industries are being developed in the south of the city of Kaunas and Karmėlava. 7 km from the city of Kaunas there is located Kaunas Free Economic Zone, occupying an area of approximately 534 hectares which has a very promising industry and logistics development potential.

The distribution pipeline length in Kaunas District is about 140 km. In Kaunas region gases are coming from arterial roads (55 bar pressure) of natural gas supply network via a gas distribution stations. Most of natural gas in Kaunas District is consumed by industrial enterprises, utilities, household consumers as well as residents. SC "Kauno energija" is a major supplier of heat and steam in Kaunas district.

Heat sources usually are located in the settlements near Kaunas and are serving their customers The main primary fuel for energy sources is natural gas. Fuel oil is the second usage. Apart from the mentioned main types of fuel, there is used peat, sawdust. In 1998-2002 was carried out a decentralization in heating systems in villages and heating systems reconstruction in towns, which enabled liquidation of uneconomical, morally and physically obsolete District's heating systems and to stop use fuel used in coal and fuel oil. Despite the relatively well-developed heat production and distribution system in the region, the demand for heat is much smaller than its ability to produce it.

In 2009 there was finished EU funded project "Kaunas Wastewater Treatment Facilities Expansion with Biological Treatment and the Extension of the Network" during which were installed water and wastewater networks in Rokai and Garliava. These networks were connected to Kaunas urban water supply and sewerage networks. Part of the wastewater treatment plant in Kaunas District is reconstructed or built new. The main problem in the District is nitrogen and phosphorus removal from wastewater, as most now operated wastewater treatment plant did not contain nitrogen and phosphorus removal.

Waste management is one of the most pressing problems in Kaunas region as it is throughout Lithuania and also in Kaunas District. Accumulation of municipal waste in landfill is by far the dominant method. In Kaunas region there is created Regional waste management

system and established a Regional waste management center, which takes care of closing of landfills and further waste management. In cities and some towns there is created container waste management system. Waste is not sorted in private residential houses. There is not well separated secondary raw materials, organic waste, and hazardous waste from the total quantity of waste. There were operated 9 landfills in Kaunas District. Currently, most landfills are rehabilitated and only Lapės landfill is still operated.

Kaunas district operates municipal waste sorting plant JSC "Super Montes“. There are three waste sorting and processing lines. The lines are specialized in glass, mixed packs and mixed household (municipal) waste lines. In mixed household (municipal) waste conveyor‘s first sorting cabin selects bulky wood and electronics group, tires and construction debris. After the initial selection further there is separated biodegradable waste. The result - initial 50-100 mm fraction biofuels, then secondary grist mill grinds the waste to the final 1-50 mm fraction fuel which can be used for cogeneration boilers, cement plants and other customers.

2.3 The use of energy resources in Kaunas District

The use of RES is planned in accordance with the energy consumption quantity and their dynamics before the planned period. Data for the use of various energy resources in Kaunas district in separate economy sectors are not enough, therefore, this study used data of the Lithuanian energy institute work [LEI, 2010]. This paper analyzes natural gas, electricity and heat consumption in the Kaunas district industry: the food industry, energetic, farming, utility consumers and residents (Table 2.1).

Table 2.1 Dynamics of natural gas consumption in Kaunas district (thousand $m^{3)}$

Economy sector	2005	2006	2007	2008	2009
Industry	413,0	496,0	387,7	347,0	328,3
Food Industry	273,0	286,0	256,7	56,5	460,3
Energetic	9678,0	10200,0	9176,3	8949,9	8263,8
Farming	4527,0	4460,0	4373,2	3349,8	2962,8
Utility consumers	4188,0	4560,0	2469,1	2604,4	5191,3
Residents	7668,0	8486,0	12240,6	10030,2	7640,1
Total:	**26747,0**	**28496,0**	**28903,6**	**25337,8**	**24846,6**

During the analyzed period, the consumption of natural gas in Kaunas district changed only slightly from 24.8 million. m^3 (2008) to 28.5 million. m^3 (2006). In 2009 compared with 2005, gas consumption fell by 7%. Most natural gas consumed in Kaunas district is consumed in energy sector (from 31.7 to 36.2%) and farming (28.7 to 42.3%).

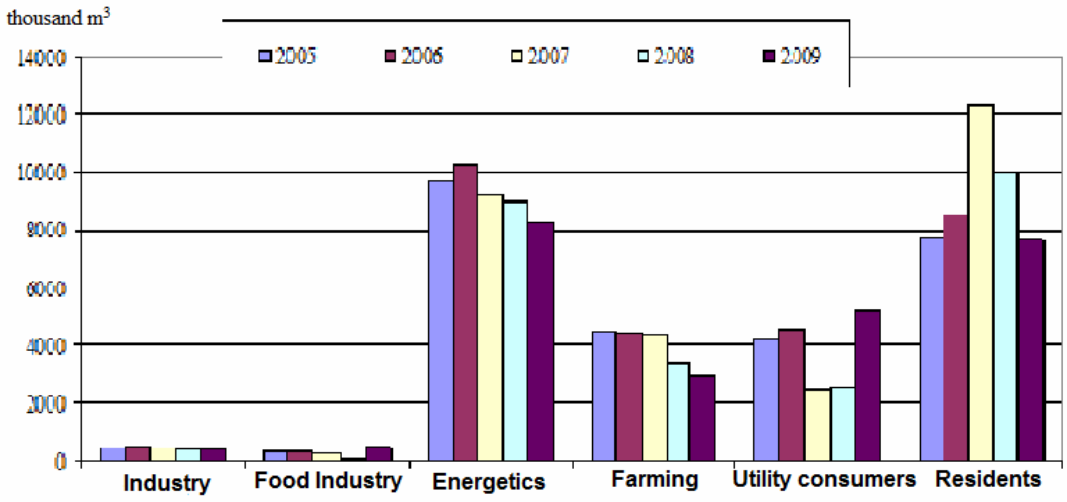

Figure 2.3 Consumption of natural gas at various sectors in Kaunas District

Electricity consumption in the period of 2005-2009 increased by 18.7% - from 155 GWh in 2005 to 184 GWh in 2009 (Table 5.2). More than 90% of the electricity consumed by households (44.2 to 52.6%) and services in the public sector (41.0 to 46.6%).

Table 2.2 Electricity consumption in Kaunas district thousand. m^3

Economic sector	**2005**	**2006**	**2007**	**2008**	**2009**
Industry	3289	3049	2789	3038	2703
Transport	308	160	176	207	225
Farming	10669	10698	9838	9228	8688
Services in the public sector	72399	76194	82397	86487	75619
Households	68573	77466	85186	96105	96983
Total:	**155238**	**167567**	**180386**	**195065**	**184218**

Noticeable that household electricity consumption is steadily increasing (Figure 5.2). This is resulted by the housing market growth in Kaunas District. Services in the public sector electricity consumption increased slightly from 72.4 GWh (2005) to 75.6 GWh. Obviously, that this is connected with the country's economic development since in 2008, electricity consumption was significantly higher - 86.5 GWh.

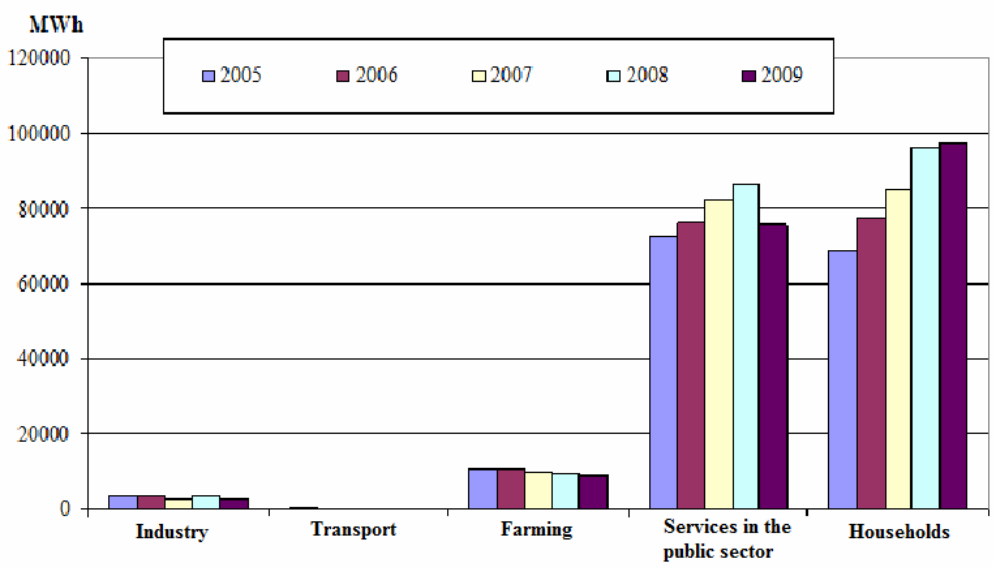

Figure 2.4 Consumption of electrical energy in different sectors of Kaunas District

Centralized heating (CH) to Kaunas District is provided in twelve residential areas. In nine of them CH systems is operated by SC Kaunas energy, in the remaining three - Kaunas District municipality-owned company JSC „Komunlinių paslaugų centras“. The District centralized heating system is installed in the following localities:

Table 2.3 List of residential areas and operators

No.	Residential area	CH operator
1	Akademija	SC “Kauno energija”
2	Domeikava	SC “Kauno energija”
3	Garliava	SC “Kauno energija”
4	Girionys	SC “Kauno energija”
5	Ežerėlis	SC “Kauno energija”
6	Jonučiai	SC “Kauno energija”
7	Neveronys	SC “Kauno energija”
8	Noreikiškės	SC “Kauno energija”
9	Raudondvaris	SC “Kauno energija”
10	Babtai	JSC “Komunalinių paslaugų centras”
11	Karmėlava	JSC “Komunalinių paslaugų centras”
12	Vandžiogala	JSC “Komunalinių paslaugų centras”
13	Vilkija	Vilkija town community of flats

Kaunas District has developed a natural gas network through which gas is supplied to customers. Gas supply organizes SC “Lietuvos dujos“ Kaunas branch. In analyzed territory residential areas, which don‘t have natural gas are: Girionys, Ežerėlis, Babtai and Vilkija. In the remaining areas natural gas supply is sufficient to be able to go to the individual heating with natural gas. In residential areas is developed gas pipeline networks which ensure gas

permeability to existing and new customers. Premises and hot water heating with natural gas plays an important role in the analyzed areas.

In Kaunas District there are installed 10 districts and one in Vilkija town community of flats boilers, with a total installed capacity of about 152 MW (Table 2.4). In 2010, heat was supplied to 336 buildings containing 5,237 apartments, and their heated area – 297600.

In 2010, Kaunas district boiler- produced and disposed 77.9 GWh of thermal energy. Most of the energy was produced using natural gas. However, four boilers were used in biofuels, and one - biogas. The heat -generating devices using renewable energy sources, power in 2010 amounted to 18.1 MW.

Table 2.4 Power of boilers and used fuel (in Kaunas District)

Name of boiler	**Installed capacity, MW**	**The maximum production capacity, MW (2010)**	**2010 realized amount of heat, GWh**	**Fuel used**
Noreikiškių	50	20,7	17,3	Biogas, natural gas
Domeikavos	7,2	4,8	6,6	Natural gas, biogas
Ežerėlio	12,9	5,8	5,3	Biofuels, peat
Garliavos	50	25,74	25,0	Natural gas
Girionių	4,0	3,69	4,1	Biogas
Neveronių	4,8	3,97	4,6	Natural gas
Raudondvario	11,9	6,17	6,7	Natural gas
Babtų	5,7	3,2	3,6	Biogas
Karmėlavos II	3,8	3,4	3,4	Natural gas
Vandžiogalos	1,4	1,3	0,9	Natural gas
Vilkijos	0,7	0,4	0,4	Biogas
Total	152,4	79,17	77,9	

According to the Lithuanian Energy Institute projections, Kaunas District can be expected of district heat reduction from 7.25 thousand toe (2010) to 6.92 thousand toe (2020). Electrical energy demand is expected to rise from 17.23 thousand toe (2010) to 23.23 thousand toe (2020). Decentralized users in households and services sectors used of energy for heating needs are expected to increase from 16.10 thousand toe (2010) to 17.39 thousand toe (2020), and decentralized users in households and services sectors energy used for hot water needs are expected to increase from 2.79 thousand toe (2010) to 3.08 thousand toe (2020). A preliminary assessment concerning Kaunas District users is that all types of consumed energy demand in 2020 expected to rise to 63.31 thousand toe (Table 2.5).

Table 2.5 Energy demand for the Kaunas District, thousand toe.

Type of energy	2008	2010	2015	2020	2030
Centralized heat supply	7,41	7,25	7,17	6,92	6,12
electric power	18,70	17,23	20,01	23,23	29,23
Decentralized heat used for space heating	16,10	16,00	16,54	17,39	17,97
Decentralized Heat for hot water supply	2,86	2,79	2,90	3,08	3,17
Need for directly used biofuel	1,37	1,55	2,25	3,38	4,02

2.4 Experience of renewable energy production and consumption in Kaunas District

Kaunas district has some experience installing renewable energy technologies in public and business facilities. As there were no planning and coordination of renewable energy it has developed spontaneously, separate initiatives from state, scientific or business level.

First installed biogas plant project was implemented in agricultural company "Vyčia" (in Kaunas District). The National Energy Efficiency Programme financed pre-testing and monitoring of the plant's work of the first year. The biogas plant was started in 1998, there were installed three horizontal 300 m^3 capacity biogas reactors capable of processing 60 tons of organic liquid waste per day. During the year the biogas plant produced up to 400 thousand m^3 biogas, which was burned in two 185 kW of power co-generators and two 300 kW water heating boilers [login or 2003, Anso N., and Bugge Maegaard J., 2000].

In 2000, another water treatment company "Kauno vandenys" started a biogas plant, where urban sewage sludge is processed into biogas. It by design is equipped with two 9 thousand m^3 capacity biogas reactors. Annual production is about 2.0 million good quality (with about 70% methane concentration) biogas. Part of biogas is used in two 1.9 MW hot water boilers. Hot water is used for company's premises and recycled heating. Since 2002 surplus of biogas is supplied to "Kauno energija" boiler Plant, which is in Lithuanian University of Agriculture (now Aleksandro Stulginskio University) area [Navickas K. 2008].

In 2008 in Lapės landfill was built biogas collection system, and cogeneration plant (combined heat and power). The project aim is to draw on Lapės landfill biogas for heat and electricity cogeneration plant. Lapės landfill started operation in 1973. The total area of the landfill is 38.7 ha. In recent years, the landfill each year an additional 110-120 thousand tones of household waste. Currently, the waste is deposited in the first collection field, covering 12.5 hectares, their volume is about 2.4 million cubic meters. According to the EU landfill directive for biodegradable landfill waste must be used biogas collection systems. It is

planned that the biogas collection and utilization of energy in 2007-2012 alone will reduce carbon dioxide emissions by 185,000 tones [GreenStream Network, 2006].

Since 2002 fall Kačerginės children sanatorium runs on solar and biofuel energy - efficient hot water and heating system. Swedish Energy Agency (STEM), using its domestic investment climate program (SICIP) which is designed to improve the energy sector and reduce pollutants, greenhouse emissions into the environment, implemented this project [AF - TERMA, 2007]. Hot-water heating system consists of a 600 kW bio-fuels (wood and waste) fired boiler and 76.2 m^2 solar collector mounted on the ground, the heat accumulator capable of supplying hot water 30-33 MWh per year.

In Kaunas District there is a very active JSC "Saulės energija" which designs, constructs and maintains photoelectric, hybrid solar and wind power stations. In 2011, the Company has designed and installed a 30 kW solar power plant that operates Kaunas district Gaižėnų village. In the middle of 2012 5 solar power plant with a capacity of 90 kW worked in Kaunas region. Kaunas District Municipality has issued 10 permits for the construction of solar power plants in general 300 kW of power in 2012.

According to SC LITGRID data, in 2011 in Kaunas District were four manufacturers producing electricity from RES (the largest - cogeneration plants in Noreikiškės and Domeikava boilers).

Table 2.6 Summary of electricity producers from RES in Kaunas District

Company (owner) name	**Manufacturer's name**	**Energies/species**	**Permit to produce electricity Date**	**Connection to the grid voltage, kV**	**Installed capacity, MW**
JSC „Energoresursai"	Lapių BJ	biogas/natural gas	2008-08-20	10	1,2
SC „Kauno energija"	Noreikiškių rajoninės katilinės elektrinė	biogas/natural gas	2005-07-01	0,4	0,75
JSC „Formula-Verner"	JSC„Formula-Verner" VE	wind	2004-03-31	0,4	0,055
JSC „Hidroenergija"	Pajiesio HE	Hydro	2008-12-02	0,4	0,1

Electricity generated from RES from 2005 to 2011 increased 3.6 times (Table 2.7), from 2248 MWh to 8169 MWh.

Table 2.7 Electricity generation from RES in Kaunas, MWh

	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Electricity production	2248	3227	3467	4079	5927	4568	8169

Differences in production is a result of an unstable supply of biogas to Noreikiškės electric boiler. Kaunas wastewater treatment plant is supplies only excess biogas, because operates 600 kW cogeneration power plant itself and is interested in its most efficient use.

2.5 Potential of RES in Kaunas District

In 2011 January 1st forest land area was 2,170 thousand ha and occupied 33.2 % of the country territory. Since 2003 January 1 this area increased by 125 thousand ha , and the country's forest cover - 1.9%. During the same period of forested land (forest) area increased by 106 thousand ha - up to 2057 thousand hectares. According to national forest inventory data, since 2003 total timber volume increased from 453.4 million m^3 to 489.8 million m^3 Average volume of wood in all forests from 226 m^3/ha in 2003 increased to 237 m^3/ha in 2011. In III -IV forest groups in mature forest timber volume accumulated over the eight years from 109.9 million m^3 to 123.9 million m^3. Current annual timber volume increment of 16.0 million m^3 has grown to 16.6 million m^3 and consists 8.0 m^3/ha. Volume per capita increased up to 151 m^3.

Kaunas District forest biomass potential is presented in Table 2.8. Cutting waste – 22.7 thousand m^3 and firewood – 51.0 thousand m^3.

Table 2.8 Forest biomass potential in Kaunas District, thousand m^3

Cutting waste	Firewood	Pulpwood	Fiberboard
22,7	51,0	22,9	15,8

Biomass energy resources can be supplemented with straw, which can be burned directly in boilers or used for the production of biofuels (pellets and briquettes). Information about the potential of straw in Lithuania is not collected, so it has to be established in accordance with sown area and grain yield. Annual straw production volumes, based on the average yields in Kaunas District are given in Table 2.9.

Table 2.9 Annual straw production in Kaunas District, thousand t.

Rape	Rye	Wheat	Barley	Oats	Total
11,65	6,24	105,91	49,17	3,92	176,88

The biggest straw potential is in wheat and barley straw (respectively 105.91 and 49.17 thousand tons). In another type of grain potential is low, and their collection is complicated by small area (rye and oats) or qualities (rape).

Biogas production potential depends on raw materials formation potential. Typically for biogas production are used agricultural production wastes (manure, feed residues, animal carcasses, plant residues), wastewater treatment plant sludge, energy crops (corn and perennial grass silage, sugar beet or fodder beet).

In Lithuania there is no statistical data on livestock and poultry manure-generation. Therefore, manure production volume is calculated according to breeding animals and birds, as well as their annual manure.

Table 2.10 Annual manure production in Kaunas district (2010 data)

	Cattle	**Pigs**	**Poultry**	**Sheep**	**Total**
Animals, heads	13828	6930	44719	829	28960
Manure, thous. t.	207,0	13,9	0,9	-	221,8

The maximum biogas production from animal manure prospects is in farms with 100 or more cattle. There are 15 such farms in Kaunas District and there are grown about 8,000 cattle. Production of pig manure is questionable due to a small farms - only 10 farms grow more than 50 pigs. Kaunas District is no large poultry farms and therefore biogas production from poultry manure does not have a good outlook.

Alternatively biogas production resources can be considered settlements collected biodegradable waste. Kaunas district, as a whole country, has no traditions and systems of collecting sorted biodegradable waste and therefore it falls into the general municipal waste stream collected by communal. In 2010, in Kaunas District were collected 21,779 tones of municipal waste. From that, about 7205 tones (about 33 %) consisted of biodegradable waste.

Almost all of them have been disposed in landfills. Just 6 tones were collected separately and composted. Even larger quantities of biodegradable waste is disposed in regional Lapės landfill, where waste is brought in from other areas. According to various assessor data, there might be collected about 50-70 thousand tone of them. It is a large potential for energy production and a significant environmental problem caused by air pollution.

In Kaunas District wastewater treatment plants annually forms 120 tons of sludge, which can also be used for biogas production. However, due to low volumes of these quantities, impractical transportation and processing for energy, also transportation expenses may be higher than produced energy.

Wind energy potential in Kaunas region is lower than in the coastal zone. The average wind speed in Kaunas District is 5.0 m/s (Figure 2.5). It's not very attractive to wind energy potential, but it is possible to build wind turbines, especially in cases where their construction is supported.

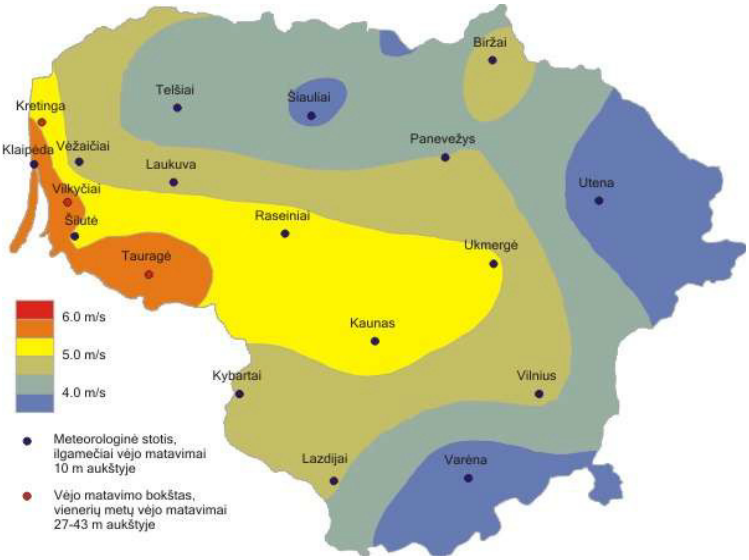

Figure 2.5 Lithuania wind speed map

Due to the larger area of urbanization and lack of space, wind energy development in Kaunas District is limited. There is a claim and the opportunity to build a small, up to 250 kW wind turbines.

Annual solar energy resources in any area are estimated at the average multiannual exposure in solar energy space planes. After assessment of solar energy resources in all areas of the country, there is concluded its annual (or other period) solar energy resources (Table 2.11), and maps (Figure 2.6).

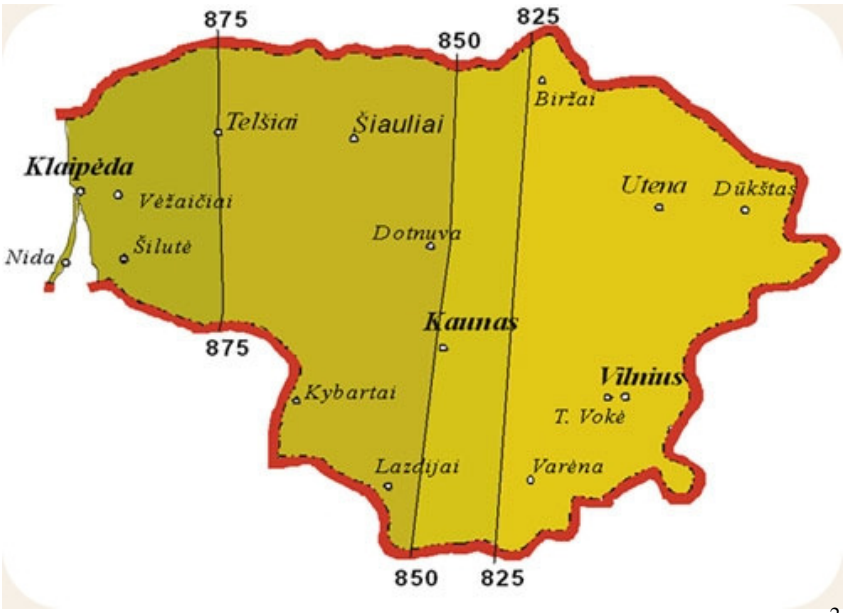

Figure 2.6 The average multiannual apparent solar energy radiation in kWh/m^2, resulting in a horizontal plane in Lithuania during the period from April 1 till October 31

Solar energy potential in Kaunas District comparing to Lithuania is close to the average. Typically, solar energy devices are installed on the roofs of buildings, in order not to use the earth's surface. The introduction of favorable electrical energy, produced in

photoelectric plant, feed-in tariffs, there has been noticed greater business and private investments. Now, however, Lithuania built photo plants are relatively small and the in the near future, in total electricity generation balance its part will be small. The initial phase it would be appropriate to install these plants on public buildings (schools, nursery schools, neighborhoods, etc.). Such investments would not give a tangible economic effect, but will have significant educational impact on the further development of the energy sector.

Table 2.11 Multiannual average sun exposure kWh/m^2 and luminosity time per horizontal surface for each month and throughout the year in Kaunas District

Indicator	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**Per year**
Sun exposure, kWh/m^2	16	33	70	99	146	155	150	138	90	52	16	19	976
Sun luminosity time, h	40	68	128	175	251	265	256	238	160	99	41	30	1751

After a preliminary assessment of RES in Kaunas District, can be said that the most promising resources are biomass, which till 2020 in RES balance will be 91% (Table 2.12).

Table 2.12 Prognosis of RES in Kaunas District for 2020

Energy resource	**Unit of measurement**	**2008**	**2020**
Wood and wood products	ktne	11,22	5,75
Straw, grass, and their products	ktne	0,02	11,16
Biogas	ktne	2,32	4,34
Shallow geothermal	ktne	0,00	0,44
Solar Energy	ktne	0,00	0,16
Wind energy	ktne	0,00	1,6
Total	ktne	13,56	23,45

3. ORGANIZATIONAL AND FINANCIAL ASPECTS

3.1 Coordination and organizational structures, creation/assignment

The Council of Kaunas District Municipality in the 28th of February 2013 in decision No TS – 58 decided to suppor the membership in The Covenant of Mayors "For local sustainable energy“, which using the experience of other municipalities, efficiently using energy and renewable energy sources, seeks to reduce CO_2 emissions 20 percent by the year 2020.

The control and operational planning of Sustainable energy action plan of Kaunas District at the political level implements Strategic Planning Committee of Kaunas District Municipality Council. Committee under its competence, examines issues related to the development of sustainable energy and control in Kaunas District Municipality, development, implementation and monitoring of Kaunas District sustainable energy action plan.

For the preparation of Sustainable Energy Action Plan Steering Committee, consisting of Deputy Director of Administration and the Environmental, Economics, Legal, General, Budget and Finances, Education, Culture and Sports, Roads and Transport, Agriculture and Urban divisions deputies and employees was drawn.

For the implementation of the plan measures Administration of Kaunas District Municipality will be responsible. Coordinator of Plan and Covenant of Mayors is appointed by Director of Administration.

3.2 Determination of Staff capacity

Demand of human resource identified by the practical volumes of European countries required for development of separate parts of sustainable energy action plan (Table 3.1). Considering the practices of European Union countries and based on the titles of the parts of action plan, 5 working groups can be made.

Table 3.1 Sustainable Energy Action Plans, Human Resources Summary

Seq. No.	Title of the Plan part	Demand of Human resources	
		Working time, h	Employees, units
1	The current situation and future vision	420	3
2	Organisational and financial aspects	140	4
3	The initial emission inventory and related information, including the interpretation of the data	360	6
4	Planned actions and measures for the entire duration of the plan till 2020	880	8
5	Self-analysis (SWOT analysis) of the Sustainable Energy	640	4

	Action Plan of Kaunas District		
	Total	**2440**	**12**

3.3 Engagement of stakeholders and citizens

Stakeholder is any group, organization or institution that somehow is interested in Sustainable Energy Action Plan, whose activities have any impact on the Plan and which property, information, resources, knowledge and so on are necessary for the successful development and implementation of the plan.

For the implementation of Kaunas District Sustainable Energy Action Plan residents, citizens (residents of Kaunas district), the municipal employees of agencies and organizations, public institutions, private companies, educational institutions and others are involved.

3.4 Budget

For the implementation and monitoring of the Sustainable Energy Action Plan of Kaunas District 0,4 billion Lt is required.

All measures provided in the plan will be transferred to the municipality's strategic development plan. For the implementation of these measures funding under the demand and financial abilities of each year will be provided approving Strategic action plan and the municipal budget.

3.5 Financial sources, investments through action plan

Investments required for the implementation of Sustainable Energy Action Plan will be provided from the budget of Kaunas District Municipality and the State budget, EU funds and other private funds. Kaunas District Municipality plans to finance part of the budget office buildings modernization and renovation of multi-residential, municipal budget offices for upgrading lighting, street lighting and spatial reconstruction costs (see Chapter 5). The other part of these investments will be attracted from EU funds, businesses and resident's personal contribution. The dissemination of information and the training of specialists from municipal institutions intended to finance 100% from the budget of Kaunas District. The installation of renewable energy sources intended to finance from private funds.

3.6 Planned measures for monitoring and follow-up

Monitoring of Sustainable Energy Action Plan consists of the planned systematic control measures, achieved results and preparation of evaluation reports. Regular reports intended to provide to the state authorities, local politicians, social partners and the Covenant of Mayors. Based on the achieved results and the possible emergence of new circumstances adjustment of Sustainable Energy Action Plan is possible. For the dissemination of achieved

results and good practices the use of electronic information tools and printed publications are planned.

4. BASELINE EMISSIONS INVENTORY AND RELATED INFORMATION, INCLUDING DATA INTERPRETATION

4.1 Final energy consumption

Final energy consumption of individual types was established on the basis of statistical information gathered from a variety of sources:

Municipal authorities (neighborhoods, schools, clinics, hospitals, municipal offices);

Natural gas, electricity and district heating network operators;

Educational institutions.

Based on the data provided by the municipal authorities, in the municipal buildings 1026 MWh of electricity were used in 2008. For the street lighting of the Kaunas district settlements 980 MWh of electricity were consumed. Service sector consumed 86,487 MWh of electricity, residential buildings - 96,105 MWh, industry - 12266 MWh. All together electricity consumers from Kaunas District consumed 196,864 MWh in 2008.

According to the data of manufacturers and suppliers from 10 thermal district heating plants and district heating networks to Kaunas district municipal buildings were supplied 5044 MWh of thermal energy, and to the residential houses - 94579 MWh. Central thermal energy suppliers served 99,623 MWh of heat to consumers in 2008. Natural gas, biofuels and biogas is used for the production of heat in regional boilers.

Other heat energy users produced heat in their own small boiler houses by burning natural gas, liquefied petroleum gas, coal and wood. In 2008, The decentralized users of the thermal energy produced and consumed 100125 MWh of heat by burning natural gas, 2,515 MWh - liquefied petroleum gas, 3220 MWh - coal, 114,788 MWh - biofuel. Total decentralized heat output in 2008 amounted to 258,181 MWh.

For the municipal organizations of Kaunas District (administration, culture, education and sports department, neighbourhoods and other units) belonged 102 cars, which consumed 161,709 liters of fuel per year in 2008: of these, 121.000 liters of petrol (1477.2 MWh) and 40.709 liters of diesel (481.6 MWh). Data of final energy consumption provided in the summary (Table 4.1).

4.2 CO_2 or CO_2 equivalent emissions

Emissions of carbon dioxide (CO_2) are calculated according to the methodology and indicators developed by the Ministry of Environment (Valstybės žinios, 2010-04-12) and other methodological literature (How to develop SEAP, 2010; Štreimikienė D., Ringailaitė, 2010).

CO_2 emissions of consumed electricity energy E_{el} are calculated based on the equation:

$$E_{ELC} = A_{ELC} \cdot C_{ELC} \quad (4.1)$$

here A_{ELC} – amount of the consumed electricity per year, MWh;

C_{ELC} – CO_2 emissions factor of electricity, tCO_2/MWh. Energy consumption in the calculations is collected using the data from table 4.1.

CO_2 emission factor of electricity is taken in accordance the methodology developed by the Ministry of Environment (Valstybės žinios, 2010-04-12), the basis of which C_{el} = 0,185 tCO_2/MWh.

CO_2 emissions of consumed thermal energy in this work are calculated based on the basic emission rates, depending on the fuel burned in specific heat production plants. In cases when several types of primary energy were used, emission factor is determined based on the total fuel balance of individual types of fuel costs.

In case of the centralized District heat production, it was found that in 2008 the production of heat in regional boiler houses 13,400 MWh of the thermal energy were produced by the combustion of biofuels, 5258 MWh - biogas and 59242 MWh - natural gas.

CO_2 emissions in Kaunas regional boilers are calculated using the equation:

$$E_{CH} = A_{CH} \cdot C_{CH}, \tag{4.2}$$

here A_{CH} – amount of the produced thermal energy in regional boiler and consumed by the consumers of Kaunas district, MWh;

C_{CH} – CO_2 emission factor of heat produced in Kaunas regional boiler, tCO_2/MWh.

CO_2 emission factor of heat produced in regional boilers determined in accordance with the equation:

$$C_{CH} = \frac{A_{NG} \cdot C_{NG} + A_{WB} \cdot C_{WB} + A_D \cdot C_D + A_{BG} \cdot C_{BG}}{A_{CH}} \tag{4.3}$$

here A_{NG} – amount of the produced and consumed thermal energy, for which production natural gas has been used, MWh;

A_{WB} – amount of the produced and consumed thermal energy, for which production wood fuel (wood chips and wood chops) has been used, MWh;

A_D – amount of the produced and consumed thermal energy, for which production peat has been used, MWh;

A_{BG} – amount of the produced and consumed thermal energy, for which production biogas has been used, MWh;

C_{NG} – CO2 emissions factor of natural gas, tCO_2/MWh;

C_{WB} – CO2 emission factor of wood biofuel, tCO_2/MWh;

C_D – CO2 emission factor of peat, tCO_2/MWh;

C_{BG} – CO2 emission factor of biogas, tCO_2/MWh.

In this work a standard CO_2 emission factors of the individual fuels were adopted (Valstybės žinios, 2010-04-12): natural gas CO_2 emissions C_{NG} = 0.205 tCO_2/MWh; peat CO_2 emissions C_{NG} = 0.381 tCO_2/MWh; wood biofuel C_{WB} = 0 tCO_2/MWh; biogas C_{BG} = 0 tCO_2/MWh.

Based on the statistical information and standard values of CO_2 emission factors for individual fuels presented above, CO_2 emission factor of heat produced in regional boilers received C_{CH} = 0.156 tCO_2/MWh. This work showed that CO_2 emissions of heat produced in regional boilers reaches 16865 tons in 2008. The higher proportion (16078 t) goes to the residential sector, and 787 tons for heating and hot water production in municipal buildings.

Decentralized, in small boiler houses, heat is generated by burning natural gas, liquefied petroleum gas, coal and wood. In this case, the CO_2 emissions E_{DCH} are calculated using the equation:

$$E_{DCH} = A_{NG} \cdot C_{NG} + A_{LOG} \cdot C_{LOG} + A_{CC} \cdot C_{CC} + A_{WB} \cdot C_{WB}, \quad (4.4)$$

here A_{NG} – amount of the produced and consumed thermal energy, for which production natural gas has been used, MWh;

A_{LOG} – amount of the produced and consumed thermal energy, for which production liquefied petroleum gas has been used, MWh;

A_{CC} – amount of the produced and consumed thermal energy, for which production coal has been used, MWh;

A_{WB} – amount of the produced and consumed thermal energy, for which production wood fuel has been used, MWh;

C_{NG} – CO2 emissions factor of natural gas, tCO_2/MWh;

C_{LOG} – CO2 emission factor of liquefied petroleum gas, tCO_2/MWh;

C_{CC} – CO2 emission factor of coal, tCO_2/MWh;

C_{WB} – CO2 emission factor of wood biofuel, tCO_2/MWh.

In this work standard CO_2 emission factors of the individual fuels were adopted (Valstybės žinios, 2010-04-12): natural gas CO_2 emissions C_{NG} = 0,205 tCO_2/MWh; liquefied petroleum gas CO_2 emissions C_{LOG} = 0,236 tCO_2/MWh; coal CO_2 emissions C_{CC} = 0,342 tCO_2/MWh; wood-based biofuels C_{WB} = 0 tCO_2/MWh.

CO2 emission factor of heat produced decentralizedly C_{DCH} established by the equation:

$$C_{DCH} = \frac{A_{NG} \cdot C_{NG} + A_{LOG} \cdot C_{LOG} + A_{CC} \cdot C_{CC} + A_{WB} \cdot C_{WB}}{A_{DCH}} \quad (4.5)$$

here A_{DCH} – amount of the decentralizedly produced and consumers of Kaunas district consumed thermal energy, MWh.

This work found that in 2008, CO_2 emissions of heat produced in small decentralized boiler rooms reaches 22220 tons. The greatest share of emissions were generated by burning natural gas - 20526 tons, 594 tons by burning liquefied petroleum gas and 1101 tons - coal. Calculated CO_2 emissions factor of the decentralizedly produced heat C_{DCH} = 0,0793 tCO_2/MWh. CO_2 emissions summarized in Table 4.2.

Table 4.1: Final Energy Consumption

Kategorija	GALUTINIS ENERGIJOS SUVARTOJIMAS [MWh]															
			Iškastinis kuras								Atsinaujinantys energijos šaltiniai					
	Elektros energija	Šiluma ir (arba) šaltis	Gamtinės dujos	Suskystintos dujos	Krosnių kuras	Dyzelinas	Benzinas	Lignitas	Akmens anglys	Kitas iškastinis kuras	Augalinis aliejus	Biokuras	Kita biomasė	Šiluminė saulės energija	Geoterminė energija	Iš viso
PASTATAI, ĮRENGINIAI IR PRAMONĖ:																
Municipaliniai pastatai ir įrenginiai	1026	5044	4128	2515					3220							15933
Paslaugų sektoriaus (ne municipaliniai) pastatai ir įrenginiai	86487		26044													112531
Gyvenamieji pastatai	96105	94579	32420									114788				337892
Municipaliniai viešojo apšvietimo įrenginiai	980															980
Pramonė (išskyrus veiklą, kuriai taikoma ES apyvartinių taršos leidimų prekybos sistema)	12266		37533													49799
Pastatai, įrenginiai ir pramonė – iš viso	196864	99623	100125	2515	0	0	0	0	3220	0	0	114788	0	0	0	517135
TRANSPORTAS:																
Municipalinis transporto priemonių parkas						482	1477									1959
Viešasis transportas																0
Privatus ir komercinis transportas	308															308
Transportas – iš viso	308	0	0	0	0	482	1477	0	0	0	0	0	0	0	0	2267
Iš viso	197172	99623	100125	2515	0	482	1477	0	3220	0	0	114788	0	0	0	519402

Table 4.2: CO_2 or CO_2 equivalent emissions

Kategorija	CO2 išlakos [t] arba CO2 ekvivalentu išreikštos išlakos [t]															
			Iškastinis kuras								Atsinaujinantys energijos šaltiniai					
	Elektros energija	Šiluma ir (arba) šaltis	Gamtinės dujos	Suskystintos dujos	Krosnių kuras	Dyzelinas	Benzinas	Lignitas	Akmens anglys	Kitas iškastinis kuras	Augalinis aliejus	Biokuras	Kita biomasė	Šiluminė saulės energija	Geoterminė energija	Iš viso
PASTATAI, ĮRENGINIAI IR PRAMONĖ:																
Municipaliniai pastatai ir įrenginiai	190	787	846	594					1101							3518
Paslaugų sektoriaus (ne municipaliniai) pastatai ir įrenginiai	16000		5339													21339
Gyvenamieji pastatai	17779	16078	6646													40504
Municipaliniai viešojo apšvietimo įrenginiai	181															181
Pramonė (išskyrus veiklą, kuriai taikoma ES apyvartinių taršos leidimų prekybos sistema)	2269		7694													9963
Pastatai, įrenginiai ir pramonė – iš viso	36420	16865	20526	594	0	0	0	0	1101	0	0	0	0	0	0	75506
TRANSPORTAS:																
Municipalinis transporto priemonių parkas						1469	4565									6033
Viešasis transportas																0
Privatus ir komercinis transportas	57															57
Transportas – iš viso	57	0	0	0	0	1469	4565	0	0	0	0	0	0	0	0	6090
KITA:																
Atliekų tvarkymas																
Nuotekų valymas																
Čia nurodykite kitas Jums svarbias išlakas																
Iš viso	36477	16865	20526	593,5	0	1469	4565	0	1101,24	0	0	0	0	0	0	81596

Atitinkami CO2 išlakų koeficientai [t/MWh]						3,05	3,09									

4.3 Local electricity production and corresponding CO_2 emissions

Kaunas district of electricity supplied from the national grid, operated by LESTO . Local electricity producers are few, and their capacities are low. In 2008, the Kaunas district were four manufacturers producing electricity from natural gas and renewable energy resources (see table 2.6) .

The base year, these manufacturers produced 4079 MWh of electricity. Two manufacturers (wind and hydro power plants) used alone renewable energy (68 MWh) . Two other producers of electricity generation using biogas and natural gas. AB LITGRID data in 2008, the two manufacturers have produced and supplied to customers 4011 MWh of electricity. 3204 MWh of electricity produced using biogas and natural gas produced 807 MWh.

Electricity produced from renewable energy sources has a zero CO2 emission factor . Power plants, where electricity was produced using natural gas and biogas , CO2 emissions are calculated using the equation :

$$E_{EL} = A_{EL} \cdot C_{EL}, \quad (4.6)$$

here A_{EL} – per year skaičiuojamuosius Kaunas district CHPs quantity of electricity generated, MWh;

C_{EL} – Kaunas district combined heat and power plants generated electricity CO_2 emission factor, kgCO_2/MWh.

The district co-generation of electricity produced CO_2 emission factor determined in accordance with the equation:

$$C_{EL} = \frac{A_{ENG} \cdot C_{NG} + A_{EBG} \cdot C_{BG}}{A_{EL}} \quad (4.7)$$

here A_{ENG} – skaičiuojamuosius per year of electricity energy, which has been used in the production of natural gas, MWh;

A_{ENG} – skaičiuojamuosius per year of electricity energy, which has been used for the production of biogas, MWh;

C_{NG} – natural gas CO_2 emissions factor, tCO_2/MWh;

C_{BG} – CO_2 emission factor for biogas, tCO_2/MWh.

Based on the statistical information used in the past for natural gas and biogas CO_2 emission factor calculated for co-generation power plants generated electricity CO_2 emission factor of 0.0412 tCO_2/MWh = CEL. Co-generation plants for the estimated CO_2 emissions in 2008

amounted to 165 tons. Data on the local production of electricity and the CO_2 emissions are given in Table 4.3.

4.4 Local heat and (or) cold production (heating and (or) cooling, heat and power plants, etc.) and corresponding CO_2 emissions

Kaunas district in 2008 produced a total of 282,738 MWh of heat. On cooling output of reliable information. Heat production in CHP plants (combined heat and power generation) in 2008 amounted to 26,981 MWh. Of these, 21,721 MWh of natural gas and 5260 MWh using biogas.

Central heating boiler plants produced 72,642 MWh. In the natural gas produced in 59242 MWh of heat from wood-based biofuels - 8100 MWh and 5300 MWh of turf.

Small boiler rooms and private boilers produced 183,115 kWh. Of these, 62,592 MWh produced by the burning of natural gas, 2,515 MWh - liquefied petroleum gas, 3220 MWh - coal and 114,788 MWh - wood fuel.

Combined heat and power co-generation of heat produced in power plants using natural gas and biogas, CO_2 emissions are calculated using the equation:

$$E_{\text{THC}} = A_{\text{THC}} \cdot C_{\text{THC}}, \tag{4.8}$$

here A_{THC} – per year skaičiuojamuosius Kaunas district cogeneration plants produced thermal energy, MWh;

C_{THC} – Kaunas district cogeneration plants produced thermal energy CO_2 emission factor, kgCO_2/MWh.

The district co-generation of electricity produced CO_2 emission factor determined in accordance with the equation:

$$C_{THC} = \frac{A_{\text{THNG}} \cdot C_{\text{NG}} + A_{\text{THBG}} \cdot C_{BG}}{A_{THC}} \tag{4.9}$$

here A_{THNG} – skaičiuojamuosius per year produced thermal energy, which has been used in the production of natural gas, MWh;

A_{THBG} – skaičiuojamuosius per year of electricity energy, which has been used for the production of biogas, MWh;

C_{NG} – natural gas CO2 emissions factor, tCO_2/MWh;

C_{BG} – CO_2 emission factor for biogas, tCO_2/MWh.

Previously calculated central heating boiler-heat produced in regional CO2 emissions factor C_{CH} = 0,156 tCO_2/MWh, and in a decentralized heat produced CO2 emissions factor C_{DCH} = 0,0793 tCO_2/MWh.

The evaluation of the heat production and the use of primary sources of the CO_2 emissions in cogeneration plants are equal E_{THC} = 4317 t, Central heating boiler plants - 12349 t, small

decentralized boiler rooms – 14521 t. Co-location of heat generation of CO_2 emissions in 2008. was reached 3187 tons. Data on thermal power production and CO_2 emissions presented in Table 4.4.

Table 4.3. Local electricity production and corresponding CO_2 emissions

Vietoje gaminama elektros energija (išskyrus jėgaines, kurioms taikoma apyvartinių taršos leidimų prekybos sistema, ir visas jėgaines (įrenginius), kurių naudingoji galia didesnė kaip 20 MW)	Vietos elektros energijos gamyba [MWh]	Energijos šaltinių sąnaudos [MWh]											CO2 arba CO2 ekv. išreikštos išlakos [t]	Atitinkami CO2 išlakų koeficientai, taikomi elektros energijos gamybai [t/MWh]
		Iškastinis kuras					Garas	Atliekos	Augalinis aliejus	Kita biomasė	Kita atsinaujinančioji energija	Kita		
		Gamtinės dujos	Suskystintos dujos	Krosnių kuras	Lignitas	Akmens anglys								
Vėjo energija	42												0	0
Hidroelektrinių energija	26												0	0
Fotogalvaninė energija														
Bendra šilumos ir elektros energijos gamyba	4011	807								3204			165	0,0412
Kita *Nurodykite* _____														
Iš viso	4079	807	0	0	0	0	0	0	0	3204	0	0	165,4	

Table 4.4. Local heat and (or) cold production (heating and (or) cooling, heat and power plants, etc.) and corresponding CO_2 emissions

Vietoje gaminama šiluma ir (arba) šaltis	Vietos šilumos ir (arba) šalčio gamyba [MWh]	Energijos šaltinių sąnaudos [MWh]										CO2 arba CO2 ekv. išreikštos išlakos [t]	Atitinkami CO2 išlakų koeficientai, taikomi šilumos ir (arba) šalčio gamybai [t/MWh]
		Iškastinis kutas					Atliekos	Augalinis aliejus	Kita biomasė	Kita atsinaujinanči oji energija	Kita		
		Gamtinės dujos	Suskystintos dujos	Krosnių kuras	Lignitas	Akmens anglys							
Bendra šilumos ir elektros energijos gamyba	26981	21721							5260			4317	0.16
Centrinio šildymo jėgainė (-ės)	72642	59242							13400			12349	0,17
Kita *Nurodykite* _____	183115	62592	2515			3220			114788			14521	0,0793
Iš viso	282738	143555	2515	0	0	3220	0	0	133448	0	0	31187	

5. FUTURE ACTIONS AND MEASURES FOR THE WHOLE PLAN VALIDITY PERIOD UP TO 2020

5.1. Reduction of energy consumption in buildings

Based on the prepared, completed and still being implemented projects of budgetary institutions (schools , kindergartens , hospitals , etc.) in Kaunas District Municipality, in the period of 2008–2020 will be modernized buildings with a total heated area of 28,000 m^2. Renovation of buildings (insulation of walls, roof and floor, replacement of old windows and doors and other measures) usually reduces the energy consumption for heating by 24-55 % [Feasibility Study "Renovation of heat generation sources in Kaunas district" UAB "Ekotermija", 2010]. Modernization of the municipal buildings will help to save 4,000 MWh of thermal energy per year (2020). For the implementation of the measure it is provided 30 million Lt (8.7 million Euros) of investments, for which it is expected to attract EU funds, the national budget and municipal funds.

CO_2 emissions were calculated assessing that 34 % percent of the energy savings will be saved in the buildings, which are connected to the district heating system, and 66 % to small decentralized boilers. In the first case will be saved 1360 MWh per year, in the second - 2640 MWh. Previously, in the Chapter 4, was showed that the factor of heat CO_2 produced in regional boilers C_{CH} = 0.170 tCO_2/MWh. Based on the value of this emission factor and expected energy savings in municipal buildings, connected to the district heating network, it is planned to reduce CO_2 emissions by 212 tons per year.

Previously established CO_2 emissions factor of small boilers C_{DCH} = 0.0793 tCO_2/MWh. In the other municipal buildings, which are heated in a decentralized way, in small boiler houses heat is generated by burning natural gas, liquefied petroleum gas, coal and wood. In 2020 by heating these buildings it is planned to save 1106 MWh of thermal energy, which is produced by burning natural gas, 674 MWh – from the combustion of liquefied petroleum gas and 863 MWh – from the combustion of coal. Reduction of CO_2 emission is calculated applying the standard values of CO2 emission factors of the individual fuels (Valstybės žinios, 2010-04-12):

CO_2 emissions of natural gas C_{NG} = 0.205 tCO_2/MWh;

CO_2 emissions of liquefied petroleum gas C_{LOG} = 0.236 tCO_2/MWh;

CO_2 emissions of coal C_{CC} = 0.342 tCO_2/MWh.

In this paper identified the reduction of CO_2 emission in buildings in which for heating is used natural gas - 227 tons, liquefied petroleum gas - 138 tons, coal - 177 tons. Reduction of energy consumption in municipal buildings by 4000 MWh, can reduce CO_2

emissions by 754 tons per year. This represents about 23 % of CO_2 emissions, which occurred in 2008.

In Kaunas region, as well as across all the country, "Multi-home renovation (modernization) program" is carried out [Valstybės žinios, 2009, No. 112-4776]. During this program the State and partly municipalitys are committed to support the renovation of flats. The goal of the program - until the end of 2020 to reduce the thermal energy (fuel) costs in apartment buildings, constructed by technical standards valid till 1993, not less than by 20 percent, that is, to reduce the calculated annual heating energy (fuel) costs in these houses at least by 1000 GWh per year, emissions of carbon dioxide into the atmosphere - not less than 230 thousand tons per year, compared with 2005 until the end of 2020. By implementing these measures it is planned to save 5700 MWh of thermal energy in Kaunas district in 2020. For the implementation of these measures it will be required 142 million Lt (about 41 million Euros) of investments. Part of these funds will invest the owners of multi- houses (15-100 %, depending on the chosen financing plan and achieved results), the other part will nominate EU funds, state budget and municipality.

Almost all apartment houses are connected to the central heating system. Accordingly to this , CO_2 emissions were calculated using CO_2 emission factor of heat produced in regional boilers- C_{CH} = 0,156 tCO_2/MWh. Based on the value of emission factor and the projected energy saving in multi-dwelling buildings, which are connected to the district heating network, it is planned to reduce CO_2 emissions by 970 tons per year.

Renovation of private residential houses is going on the initiative of the owners. Owners are changing windows and doors, insulating the walls and other partitions. It is planned that these measures will help to save about 7360 MWh of thermal energy (about 15 % from the current consumption) in 2020. Private houses are usually heated by their own boilers combusted with biofuels (about 78 %) and natural gas (about 22%). In 2020, it is planned to save about 4860 MWh of thermal energy, for the production of which natural gas is used of and 2,500 MWh - where biofuels are used.

Standard values of CO_2 emission factor for natural gas is C_{NG} = 0.205 tCO_2/MWh, biofuels of wood C_{WB} = 0 tCO_2/MWh. In 2020, it is expected to reduce CO_2 emissions volume by 994 tons in the private residential sector. This represents about 15 % of CO_2 emissions, which occurred in 2008.

Data on energy reduction measures in buildings and CO2 emissions provided in Table 5.1.

Table 5.1. Measures reducing energy consumption in buildings

Seq. No.	Actions	Expected energy savings per year, MWh	Expected reduction of CO_2 per year, t	Responsible for the implementation	Period	Demand for funds	Sources of funding
1.	Modernization of the municipal buildings	4000	754	Department of Environment	2009-2020	30 mln. Lt (8,7 mln. EUR)	EU funds, national budget, the municipal funds
2.	Refurbishment and renovation of multifamily residential houses	5700	970	Department of Environment, UAB "Komunalinių paslaugų centras"	2009-2020	142,0 mln. Lt (41,1 mln. EUR)	EU funds, national budget, municipal funds private funds
3.	Renovation of private houses	7360	994	Department of Environment	2009-2020	12 mln. Lt (3,5 mln. EUR)	Private funds
4.	Modernization of public institutions (high schools, research institutes, agencies, etc.).	2570	347	Department of Environment	2009-2020	19 mln. Lt (5,5 mln. EUR)	EU funds, national budget, private funds
5.	Reconstruction of heating and hot water systems	1200	162	Department of Environment	2009-2020	9 mln. Lt (2,5 mln. EUR)	EU funds, national budget, private funds
	Total	20833	3227	-	-	203 mln. Lt	-

5.2 Renewable energy deployment, promotion and stimulation

It is planned to build wind and solar power, biogas power plants, geothermal heating systems, sub-bottom and increase the share of biofuels in the municipal budget institutions heating balance in Kaunas district for 2008-2020 period.

It is planned that in 2020 in biogas plants operating in Kaunas district will be produced about 23260 MWh of energy, of which will be generated about 10470 MWh of electricity and 12790 MWh - thermal energy. For the construction of biogas plants will be required about 32 million Lt (9,3 million Euros), which will invest business companies.

Usually this electrical energy is supplied to the national grid and heat is used for heating adjacent buildings and industrial uses (drying of products and wood, in greenhouses, production of animal feed or food and so on.). In this paper it is planned that they will be consumed in industrial applications, replacing natural gas.

Calculating reduction of CO_2 emissions standard factor of CO_2 emissions for electricity C_{ELC} = 0.185 tCO2/MWh was used. After the calculations it was revealed that electricity produced in the biogas plants of Kaunas district will reduce CO_2 emissions by 4303 tons per year. Thermal power produced in biogas plants will reduce CO_2 emissions by 2623 tons per year.

In this study it is estimated that in 2020 wind and solar power plants will generate accordingly 18610 MWh and 1860 MWh of electricity in Kaunas district. All this energy will be transmitted to consumers via the national grid. In this case, for the calculation of CO_2 emissions standard factor of CO_2 emission for electricity C_{ELC} = 0.185 tCO_2/MWh was used. Electricity produced in wind powe plantsr will reduce CO2 emissions by 3443 tons per year, and solar power - 344 tons.

Sub-bottom geothermal systems are mostly installed for the heating of private residential houses. Calculating reduction of CO_2 emission, CO_2 emission factor for decentralized thermal power generation - C_{DCH} = 0.0793 tCO_2/MWh was used. In this paper it is stated that in 2020 these systems will generate 5,120 MWh of thermal energy in Kaunas district. It is estimated that sub-bottom deployment and use of geothermal energy for heating of buildings will reduce CO_2 emissions by 406 tons per year in Kaunas district.

Currently, in Kaunas district wood fuel is successfully used for heating of industrial, municipal and residential buildings. In this work it is planned that by 2020 the share of biofuels in production of heat will increase by 65,940 MWh in Kaunas district. Some of it will be installed in the central heating system (about 18360 MWh), the rest (about 47580 MWh) – will be used for production of decentralized heat. The use of biofuels in district heating systems will reduce CO2 emissions by 2,864 tons per year, and decentralized - 3773 tons. For

the calculation of the first case CO_2 emission factor of heat produced in regional boilers C_{CH} = 0.156 tCO_2/MWh was used and for the second – for the decentralized heat production C_{DCH} = 0.0793 tCO_2/MWh.

Table 5.2. Renewable energy deployment, promotion and stimulation

Seq. No.	Actions	Expected energy savings per year, MWh	Expected reduction of CO_2 per year, t	Responsible for the implementation	Period	Demand for funds	Sources of funding
1.	Construction of biogas power plants, the use of local raw materials	23260	4303	Department of Environment, Department of Agriculture	2008-2020	32 mln. Lt (9,3 mln. Eur)	Private funds
2.	Construction of wind power plants	18610	3443	Department of Environment, Department of Urban Development	2008-2020	18,6 mln. Lt (5,4 mln. Eur)	Private funds
3.	Construction of solar power plants	1860	344	Department of Environment, Department of Urban Development	2008-2020	9,3 mln. Lt (2,7 mln. Eur)	Private funds
4.	Instalation of sub-bottom geothermal heating systems in buildings	5120	406	Department of Environment, Department of Urban Development	2008-2020	3,5 mln. Lt (1,1 mln. Eur)	Private funds
5.	The use of biomass for heating of municipal budgetary institutions and private buildings	65940	8902	Department of Environment, UAB “Komunaliniu paslaugu centras”	2008-2020	125 mln. Lt (36,2 mln. Eur)	EU funds, national budget, Municipal funds private funds
6.	Dissemination of information	-	0	Department of Environment, University of Aleksandras Stulginskis	2011-2020	20 tūkst. Lt (5,8 tūkst. Eur)	Municipal funds
7.	Training of the specialists of municipal budget institutions	-	0	Personnel Department	2011-2020	50 tūkst. Lt (14,5 tūkst. Eurų)	Municipal funds
	Total	114790	15133	-	-	189 mln.litų	-

5.3 Dissemination of energy saving in public and manufacturing sector

Kaunas District Municipality is interested in energy saving, therefore it is set measures for use of cost-effective lighting schemes in municipal budget institutions for indoor lighting. It is planned to execute the modernization for the municipal budget institutions indoor electric lighting systems, to replace old fixtures with incandescent lamps in fixtures with economical fluorescent lamps. For the implementation of these measures it is planned to invest 800 thousand Lt. It is planned that these measures would save 150 MWh of electricity per year.

For the lighting of streets and areas it was consumed 980 MWh of electricity in 2008. Embracing frugal light sources and automatic control systems it is expected to reduce annual energy consumption by 120 MWh (about 12%). For the implementation of these measures it is planned to invest 1.1 million Lt.

Electricity rates are rising constantly, therefore is increasing the motivation to save energy in companies of services sector, residential buildings, industry and agriculture. This paper provides that after installation of energy-saving measures (modernization of the electric lighting systems using frugal electrical equipment and so on.) in the service sector they will save 4320 MWh (about 5 % of the quantity used now) in 2020 . Energy savings in residential houses are possible through frugal electric lighting equipment, more efficient household electrical appliances. It is planned that this sector will save 4,800 MWh in 2020 (about 5 % of the quantity used now). Businesses, farmers and agricultural companies continually seek of cost reduction. Electrical energy in the manufacturing sector can be saved by using more efficient technology and lighting facilities and equipment, improving technology of production and the instaling modern methods of energy management. With these tools it is planned to save 1840 MWh (about 15%) in industry and agriculture.

In the calculation of reduction of CO_2 emissions standard CO_2 emission factor for electricity C_{ELC} value = 0.185 tCO_2/MWh was used. After the calculations it was revealed that after the implementation of energy saving measures in Kaunas district public sector CO_2 emissions will be reduced by 50 tons, the service sector - 799 tons, in the residential sector - 888 tons, in industry and in agriculture - 340 tons. All energy saving measures would reduce the annual electricity consumption of Kaunas district by 11230 MWh and CO_2 emissions – by 2078 tonnes.

Table 5.3. Dissemination of energy saving in public and manufacturing sector

Seq. No.	Actions	Expected energy savings per year, MWh	Expected reduction of CO_2 per year, t	Responsible for the implementation	Period	Demand for funds	Sources of funding
1.	Use of frugal lighting schemes in municipal budget institutions for indoor lighting	150	28	Department of Environment	2009-2020	0,800 mln. Lt (0,231 mln. Eur)	EU funds, national budget, municipal funds
2.	Reconstruction of areasl and street lighting by frugal light sources and automatic control systems	120	22	Department of Environment	2009-2020	1,1 mln. Lt (0,32 mln. Eur)	EU funds, national budget, municipal funds
3.	Energy savings in companies and institutions of service sector	4320	799	Department of Environment	2009-2020	14,4 mln. Lt (4,2 mln. Eur)	EU funds, private funds
4.	Electricity savings in residential buildings	4800	888	Department of Environment	2009-2020	6,7 mln. Lt (1,9 mln. Eur)	EU funds, private funds
5.	Electricity savings in industry and agriculture	1840	340	Department of Environment	2009-2020	2,8 mln. Lt (0,8 mln. Eur)	EU funds, private funds
	Total	11230	2078	-	-	25,8 mln. Lt	-

Planned energy saving and renewable energy measures will save approximately 146,850 MWh, or 28% less than was used in 2008 (Table 5.4) in 2020. Most of the energy will be saved implementing and promoting renewable energy sources - 78%.

Table 5.4. Outstanding summary of measures for energy efficiency and renewable energy

Seq. No.	Measure	Expected savings per year, MWh	Expected reduction of CO2 per year, t	Expected reduction of CO2 per year,%
1.	Reducing energy consumption in buildings	20833	3227	15
2.	Deployment of renewable energy sources	114790	15133	75
3.	Saving of energy resources in public and manufacturing sectors	11230	2078	10
	Total	146853	20438	100

Energy saving measures will reduce CO2 emissions by 20238 tons per year, or 25% of the 2008 level. The greatest impact on the reduction of CO2 is from the installation of renewable energy sources (about 75%).

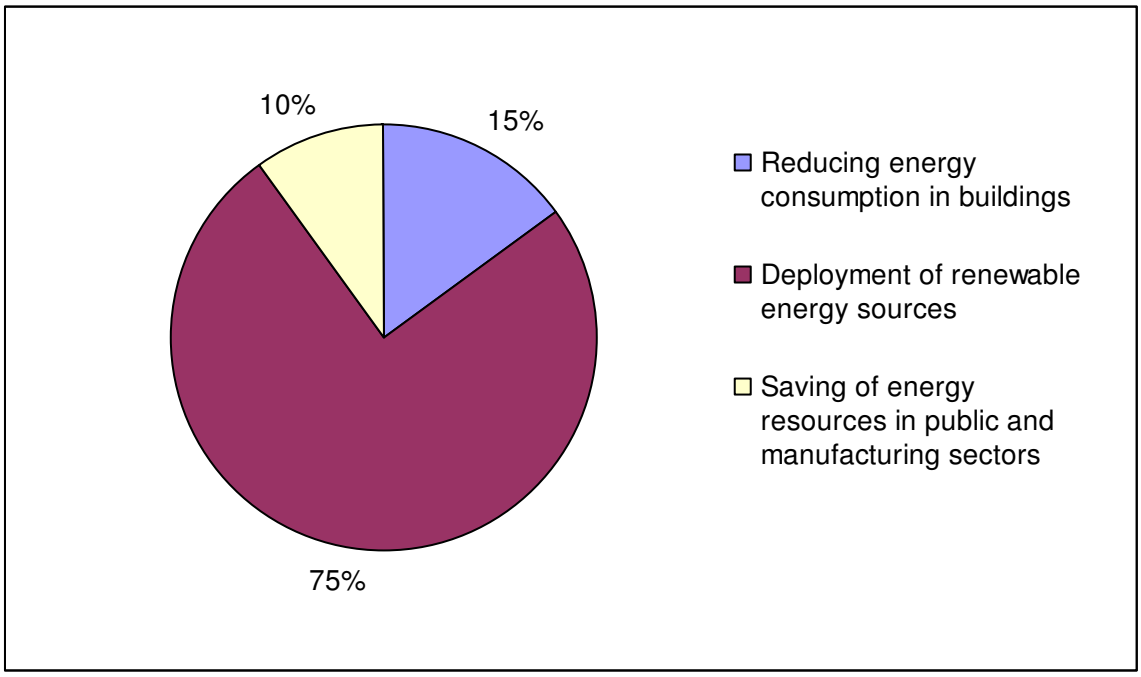

Figure 5.1. Estimated measures for reducing carbon dioxide emissions

6. SELF-ANALYSIS OF SUSTAINABLE ENERGY ACTION PLAN IN KAUNAS DISTRICT (SWOT ANALYSIS)

STRENGTHS	
1.	Sustainable energy and renewable energy sources (RES) development is regarded as one of the priority directions of Lithuanian Energy Strategy
2.	Lithuania has set up the basic legal framework and support system for sustainable energy and development of RES
3.	The country's rural development policy encourages farmers to energy production activities
4.	The district operates an active farmers, residential communities, energy, business associations, promoting sustainable energy and renewable energy
5.	Kaunas district has preconditions for the development of renewable energy on a well-developed energy infrastructure
6.	The district forms renewable energy market
7.	District high schools and other institutions are pooled smart enough potential to develop sustainable energy and RES projects
8.	The area has large highly skilled labor resources
9.	The district has a good practice experience in RES projects
10.	In district public buildings are implemented EU funded projects.
11.	Kaunas district farmers are educated, proactive, and actively participate in seminars and training, promotes the use of RES
12.	Rural communities and housing associations interested in energy conservation and renewable energy technologies installation
13.	District energy companies in their development strategies are intended to save energy resources and introduce RES technologies
14.	Businesses interested in investing in sustainable energy and renewable energy projects
15.	The district operates an active company engaged in various types of renewable energy production
WEAKNESSES	
1.	Subordinate legal acts related to the competence of municipalities, their actions and responsibility in drafting and implementing renewable energy development plans are insufficient
2.	Lack of educational activities on sustainable energy
3.	Scarce financial resources to support RES and energy saving projects
4.	Municipality is insufficient of financial instruments to promote sustainable and renewable energy development in the area
5.	Administrative (human) resources of energy analysis, energy-saving measures in the implementation of RES deployment are insufficient
6.	There is a lack of reliable statistical information on the use of energy resources, not collected information on the use of RES in municipality
7.	The municipality is not included directly in the promotion of the use of RES policy.
8.	Insufficient public and local government staff knowledge and understanding of the energy savings and RES use of technology and benefits.
9.	Municipality has no special unit engaged in sustainable and renewable energy resource development organization

10.	Lack of cooperation between government institutions, businesses, rural communities, population and residential communities development and use of sustainable energy and renewable energy projects
11.	Insufficient exploitation of potential indigenous energy resource
12.	Undeveloped cycling infrastructure
13.	There is insufficient information about the dissemination of best practices through the introduction of energy-saving and renewable energy projects in Lithuania and abroad
OPPORTUNITIES	
1.	Increasing energy demand from a growing housing stock and business development
2.	The area has high energy biomass, municipal and industrial waste resources that could be used for energy purposes
3.	The growing integration of RES into the biofuel market in electricity and heat networks access
4.	Large abandoned agricultural land, especially in remote areas and less favored areas
5.	There are opportunities to use EU Structural Funds and the European rural development support.
6.	Can significantly reduce the cost of the municipal budget, the introduction of energy-saving and RES projects
7.	Good examples and information tools can be deployed in an innovative approach to energy resources in the district schools for students and the general public
8.	The possibility of the development of RES and energy saving technology businesses in the area, creating new jobs and increase employment and income of the district budget
9.	Using Waste materials can reduce energy use in global and local pollution
10.	Develop a research and educational activities through the district educational and scientific potential, to develop and deploy new energy-saving and renewable energy technologies
11.	Create a local unit engaged in sustainable energy project development, implementation, monitoring and dissemination of information
12.	Increase the local authorities and residents and business cooperation in the development and implementation of energy savings and RES projects
THREATS	
1.	Major energy supply system on import of energy resources and their prices volatile
2.	High energy from renewable sources cost, so only part of them can compete with ordinary energy resources
3.	Unstable RES and final energy pricing, delaying their projects
4.	A complex combination of EU and national funds, and project development and administration
5.	Implementation of RES projects encountered administrative procedures governing the use of RES power stations, creating barriers to the requirements and limitations
6.	Importance of sustainable energy and renewable energy projects cost
7.	Unfavorable to the banks of the renewable energy project financing
8.	Underdeveloped information system in support of operational monitoring of sustainable energy development and promotion

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30. Šalies savivaldybėse esamų atsinaujinančių energijos išteklių (biokuro, hidroenergijos, saulės energijos, geoterminės energijos) ir komunalinių atliekų panaudojimas energijai gaminti. Lietuvos energetikos institutas, 2009. 357 p.

31. Štreimikienė D., Ringailaitė I. Energetikos ir klimato kaitos švelninimo veiksmų planavimas: Vadovas Lietuvos savivaldybėms. VšĮ „DVI Darnaus vystymo iniciatyvos“, 2010. – 84 p.

32. Viešuosius interesus atitinkančių paslaugų elektros energetikos sektoriuje sąrašas// Žin., 2009, Nr. 140-6158.

8. CONCLUSIONS

1. Sustainable Energy Action Plan of Kaunas District is drawn up for the period of 2008–2020.

2. Centralized heating accounted 7,41 thousand, electricity consumption - 18.7 thousand tne, decentralized heat 16.1 thousand tne, decentralized energy used for hot water - 2.86 thousand tne, directly used demand for biofuel - 1.37 thousand toe in Kaunas region in 2008.

3. In 2020, it is projected the decrease in the amount of district heat to 6,92 thousand tne, consumption of electricity power will increase to 23.2 thousand tne, the usage of the decentralized heat will increase to 17.39 thousand tne, demand of the decentralized energy used for hot water will increase to 3.08 thousand tne, demand of the directly used biofuel will increase to 3.38 thousand tne.

4. The introduction of energy consumption reducing measures in buildings will reduce energy consumption by 20833 MWh and CO2 emissions will fall by 3227 tons per year. To implement these measures 203 million Lt or 58.8 million Euro of investment it is needed.

5. Deployment, promotion and stimulation of renewable energy sources will help to reach annual energy production of 114790 MWh in Kaunas District. These measures will reduce CO2 emissions by 15133 tons per year. To implement these measures investments of 188.5 million Lt or 54.6 million. Euro is needed.

6. The most promising renewable energy source for Kaunas district in 2020 will remain biomass which will compound 91% in RES balance. Will have to grow the usage of straw and energy crops and production of biogas. Other types of RES have limited resources and limited opportunities to be used.

7. The introduction of energy saving resources in the public sector and in the production will decrease energy consumption by 11230 MWh and CO2 emissions will be reduced by 2078 tons per year. To implement these measures investments of 25.8 million Lt or 7.5 million Euro is needed.

8. Measures of renewable energy and energy conservation will save approximately 146850 MWh in 2020 or 28%less than was used for the 2008.

9. Energy efficiency and usage of renewable energy will reduce CO2 emissions by 20238 tons per year or 25% of the 2008 level.