ENERGY EFFICIENCY ACTION PLAN FOR TALLINN

INTRODUCTION

Tallinn's present Action Plan for Energy Efficiency, which has been developed for the period 2010 to 2020, analyses energy-saving opportunities in Tallinn and sets out guidelines for the development of Tallinn's energy economy by the year 2020.

The main objective of the Action Plan is to reduce energy consumption and greenhouse gas emissions, and to increase the renewable energy share.

In February 2009, Tallinn joined the *Covenant of Mayors*, the international co-operation of communities. Accordingly, the city has undertaken the duty to reduce its CO_2 emissions by 20% by 2020 as a result of a 20% improvement in energy efficiency and a 20% share of renewable energy sources in the energy mix.

The estimates of energy consumption contain data for the period from 2007 until last year, providing full details of energy consumption. The present Action Plan considers energy consumption in Tallinn and the corresponding social and economic areas in 2007. General energy consumption in Estonia (incl. Tallinn) is at an average level among the European Union states.

In Tallinn 2007, the share of renewable energy sources in the fuel balance was 8.2%. Wood fuels comprised the major part in individual heating and small boiler rooms. Natural gas has been the most used among all kinds of power-generating fuel, and comprised the main fuel in Tallinn’s central heating plants. Iru Power Station, which produced more than half of Tallinn's central heating in 2007, has also used natural gas as its fuel.

The share of fuel used in transport has been remarkable, - more than 50% of total fuel consumption. In Tallinn 2007, electricity consumption amounted to 1996 Gwh, which was mainly supplied by Eesti Energia AS. Less than 1% of the consumed electricity has been produced by those of Tallinn's small power and heating stations based on gas power. Though the main electricity users have been manufacturing plants and the general population, a considerable amount of electricity has also been consumed by the city facilities. The major share of electricity has gone on street lighting, which uses about 2% of the total electricity consumed in Tallinn. AS Tallinna Vesi also uses a significant amount of electricity.

Energy production and the consumption structure in Tallinn is to be substantially changed by 2020. At the end of 2008, the new Tallinn Power Plant, based on renewable energy and located in the Väo old limestone quarries, was put into operation. New plant supplies Tallinn with central heating and electric energy.

In the coming years, significant changes are to take place in Tallinn's waste management due to the improvement of waste sorting and utilization. Waste burning plant is likely to be built, which would process some part of the household waste. These plants could also produce some degree of heating and electricity in Tallinn.

In addition to the biofuel Tallinn Power Station (wood fuel and peat), which currently supplies Tallinn with more than 22% of its central heating and 9% of its electricity consumption, it is reasonable to reduce the proportion of natural gas used for the city's heating supply (which nowadays amounts to more than 70%), and to increase the amount of the energy in Tallinn energy balance produced from less expensive local fuels (wood fuel and peat). For this purpose, the merging of the main districts' heat distribution network will be completed; this will enable the maximum use of the current biofuel production potential and run a system supplementing biofuel energy resource(s).

For instance, a supplementary 75MW station would enable the increase of the share of biofuel heating in Tallinn's heating supply network up to 50%.

In 2010, construction of a new heating main between Tallinn's Western (Lasnamäe, Kopli) and Eastern (Mustamäe, Õismäe, North Tallinn) districts was started, upon the completion of which Tallinn's major heating supply districts and their networks will have been merged. The named works are to be completed by autumn 2011. This interconnection will improve the efficiency of the power and heat supply network, and increase the share of heating energy produced from less expensive biofuel in Tallinn's Power Plant up to 25-30% in the city's heat power balance.

Furthermore, the construction of a heat pump system near the sewage treatment plant in Paljassaare is being discussed, which would use the energy from sewage water; the approximate capacity of such a system would be 20MW and it would cover 6-7% of the city's heat consumption.

The higher electricity consumption caused by a rise in economic activity will be covered by the savings made, and, in 2020, electricity consumption will presumably stay at the same level as in 2007. Both power plants and society play significant roles in this process: the use of energy-saving light bulbs and changing behavioural patterns with regard to rational energy consumption are essential.

It is also essential to save energy in housing services. House insulation and the construction of new energy-efficient houses will enable the saving of up to 30% of consumed heat. Buildings' energy audits and the energy performance certificate system will contribute to the achievement of this objective. The Action Plan aims to reduce heat consumption by 2% annually. Thus, by 2020, heat consumption will have been reduced by 23% in comparison to 2007.

As for the transport sector, it is vital that at least 10% of Tallinn's transport fuel consumption be satisfied by biofuel, so it is necessary to introduce biofuel both to the city's public and private transport.

In general, the development of guidelines for society and the encouragement of rational energy consumption behaviour have a significant role in energy economy. Nowadays, through changing behavioural patterns in regard to energy consumption, it is possible to save 10-15% of electricity without the involvement of any technical equipment. This holds true for both electricity and transport consumption as well other social sectors.

All opportunities are to be used within energy-saving investments: the city's monetary funds, the state budget and private sectors, and the involvement of the whole population in the use of energy-saving ways and means.

For the successful implementation of the energy-saving project it is necessary to carry out a precise calculation in this respect and keep it under control. A structural unit must operate in the city to co-ordinate and control the city's energy consumption. Besides, possible barriers to the achievement of the targeted energy-saving level must be foreseen and the appropriate preventive measures taken.

By applying the methods set out in the present Action Plan it is possible to save a significant amount of energy. In the housing services sector, it is possible to save 20-25% of the consumed heat and 10-15% of electricity. At least 50% of heat consumption in Tallinn can be covered by renewable fuel, using which 16% of consumed electricity is generated in Tallinn's power and heating plants. Considering the total amount of energy consumption, including purchased electricity, it is possible to cover more than 28% by using renewable energy.

In Tallinn, CO_2 emissions into the atmosphere from burning fossil fuel can also be reduced by 370 000 tones or 23%. Due to changes in the Estonian electricity production structure, the amount of indirect CO_2 emissions along with the amount of purchased energy can be reduced by about a half.

With the application of measures set forth in the present Action Plan, Tallinn will fulfil the duties undertaken by the Covenant of Mayors to reduce its CO_2 emissions into the atmosphere by 20%, as a result of 20% increase in energy efficiency and a 20% share of renewable energy sources in the energy mix.

1 Plan objectives and procedure

1.1 Plan procedure

The Plan procedure is based on instruction materials and recommendations for the preparation of energy efficiency strategic plans. The Action Plan preparation follows the same principles as prescribed in the preparation of the energy efficiency strategic plans of other European States. The Action Plan contains the following aspects:

- analysis of the current situation in all industries and spheres of activities related to the energy economy;
- assessment of the previous development programmes for the energy economy and the results achieved in other projects;
- the state of Tallinn's energy economy and a comparison of development programmes directions with other European States;
- efficient energy economy planning;
- recommendations for the development of the city's energy economy and encouragement of rational energy consumption behaviour.

The Action Plan procedure follows the recommendations and requirements prescribed by the regulations currently valid in Tallinn, in the Republic of Estonia, and in the European Union, as well as other development programmes and proposals (see the List of References), which have been worked out for the development of industries and spheres of activities related to the energy economy.

1.2 Plan framework

The present Tallinn's Action Plan for Energy Efficiency provides a detailed analysis of energy consumption in Tallinn for the year 2007. In addition to the estimation of the direct energy consumption (fuel, electricity, heating), it is essential to take into account all large-scale economic activities that have a direct impact on energy demand or energy consumption, such as construction, city planning, transport sector, waste treatment, water industry, streets lighting, and the use of land. It is also important to encourage an energy-efficient mindset in both enterprises and residents and rational energy consumption behaviour.

The analysis of the current situation allows the setting out of clear directions for energy consumption which would secure the reduction of energy consumption and the amount of CO_2 emissions into the atmosphere by at least 20% in comparison to the base year. The year 2007 is used as the base year for the current situation analysis, which gives a full view of the present consumption and situation. The analysis of the current situation has been made by using publicly available data, statistical results, and data from large-scale power stations.

To achieve the set targets, the development programme proposes the activity concept, sets development objectives, and major essential strategic aspects in both direct energy consumption and in economic activities that have a significant impact on this issue.

The Action Plan presents possible measures for the achievement of set targets and sets precise timeframes for work performance. The Action Plan provides for the estimation of possible expenses related to the fulfilment of the project, as well as the volume of possible investments and potential sources of funds. The fulfilment of the Action Plan will require the securing of state financing, private sector and the European Union funds.

The Action Plan presents precise, feasible, and monitored guidelines for efficient energy use and works out specific opportunities to save energy as well as the total scope that can be achieved. The Action Plan prescribes methods for the successful estimation and principles of its disclosure. A classification system must be applied to all aspects of the statistical data analysis, and available data analysis must be further advanced.

The Action Plan estimates possible barriers to the achievement of the targeted energy-saving level and proposes appropriate preventive measures.

For the successful performance of the Action Plan, appropriate energy-saving measures must be undertaken not only by the municipal government but also by business enterprises and residents. It is essential to organize energy efficient days to encourage people to change their consumption habits.

The Action Plan presents guidelines and prescribes accurate methods to achieve the aimed-for energy-saving level and to reduce the amount of CO_2 emissions in Tallinn by at least 20% by 2020.

1.3 Covenant of Mayors

In February 2009, Tallinn joined the *Covenant of Mayors,* the international co-operation of communities. Accordingly, the city has undertaken the duty to take steps to reduce the impact on climate warming. Tallinn aims reduce its CO_2 emissions by 20% by 2020 as a result of a 20% improvement in energy efficiency and a 20% share of renewable energy sources in the energy mix.

The Principles of the Covenant of Mayors were set out in 2006. The Covenant of Mayors is the initiative of European Union's Energy Commissioner Andris Piebalgs, the representative of the Republic of Latvia. The Covenant was signed at a special ceremony in Brussels on the 10th of February, 2009. In two weeks, in the course of the first Technical Conference, the Covenant of Mayors has already been signed by more than one hundred Mayors.

Nowadays, more than 1200 of both EU and non-EU members have joined the Covenant of Mayors. Spain, one of the first signatories of the Covenant of Mayors, has been particularly active, so more than 300 cities have joined the Covenant, and several districts have joined its base framework. In general, Spain has achieved significant success in the overall economy and, especially, in the development of the energy economy after it joined the European Union in 1986.

In Estonia, three cities have joined the Covenant of Mayors: Tallinn, Rakvere, and Kuressaare. These cities have significantly advanced in the development of the energy economy.
With regard to the Covenant of Mayors, on 9 March 2007, the European Union adopted the Energy package "Energy for a Changing World." According to this package, the cities undertake the commitment to reduce their CO2 emissions by 20%, through the implementation of the Sustainable Energy Action Plan, as a result of a 20% improvement in energy efficiency and a 20% share of renewable energy sources in the energy mix.

By signing the Covenant, the mayors commit their cities to energy-efficient consumption. Tallinn's Action Plan for Energy Efficiency provides guidelines on how to meet the obligations in regard to the energy efficiency, the use of renewable energy, and the reduction of CO_2 emissions which Tallinn had undertaken by joining the Covenant Union.

2 Situation Analysis

2.1 Energy generation and consumption

2.1.1. Consumption of power-generating fuel

Data on Tallinn's fuel consumption have been obtained from the Department of Statistics[1], Information technology centre of the Ministry of Environment[2], collected volume "Tallinn in numbers,"[3] and from various enterprises. Unfortunately, these sources provide different data due to the different principles used for the preparation of reports.

The Department of Statistics' reports represent data on the energy consumption of those enterprises having their main office in Tallinn. So, for instance, the heat consumption of AS Eraküte Valga (whose main office is in Tallinn at Punane St. 36) and of other boiler-houses located in Estonia is included in Tallinn's statistical consumption data. Data from the Department of Statistics have also been used in the collected volume "Tallinn in numbers," which may also contain systematic inaccuracies, as mentioned above. The present Action Plan aims to represent a real view of Tallinn's fuel consumption by the use of data obtained from enterprises and other sources.

Table 1. Consumption of power-generating fuels and purchased heat in Tallinn 2007

Fuel	Unit	Energy generation	Industry and construction	Business and service	Household	Total demand	Heating value	Energy (GWh)	Consumption share (%)
Coal	thousand tons			1	7	8	7,5	60	1,4
Peat briquette	thousand tons				4	4	4,4	18	0,4
Wood fuel	thousand cubic meters		2	10	130	142	2,1	289	7,0
Wood chip and pellet	thousand cubic meters	50	6		100	156	1,7	268	6,2
Natural gas	mln m³	165	34	31	28	258	9,3	2407	56,3
Liquid gas	thousand tons		1		2	3	12,7	38	0,9
Biogas	thousand tons			3		3	5,3	16	0,4
Shale oil	thousand tons	1	1	1		3	10,9	33	0,8
Light fuel oil	thousand tons	2	6	1	4	13	11,8	153	3,6
Heat purchased from Iru Power station	GWh		89	167	730	986		986	23,1
Total energy consumption	**GWh**	**1660**	**515**	**523**	**1576**	**4274**		**4277**	100,0
Consumption per capita	**MWh per capita**							**10,8**	

Table 1: "Consumption of power-generating fuels and purchased heat in Tallinn 2007" represents all sorts of fuels consumed in Tallinn in the course of energy generation, industrial works, service, and household activities. The table includes all kinds of fuel, such as solid, liquid, and gas fuel. Transport fuel consumption is separately analysed in the chapter 3.3 (Transport and traffic).

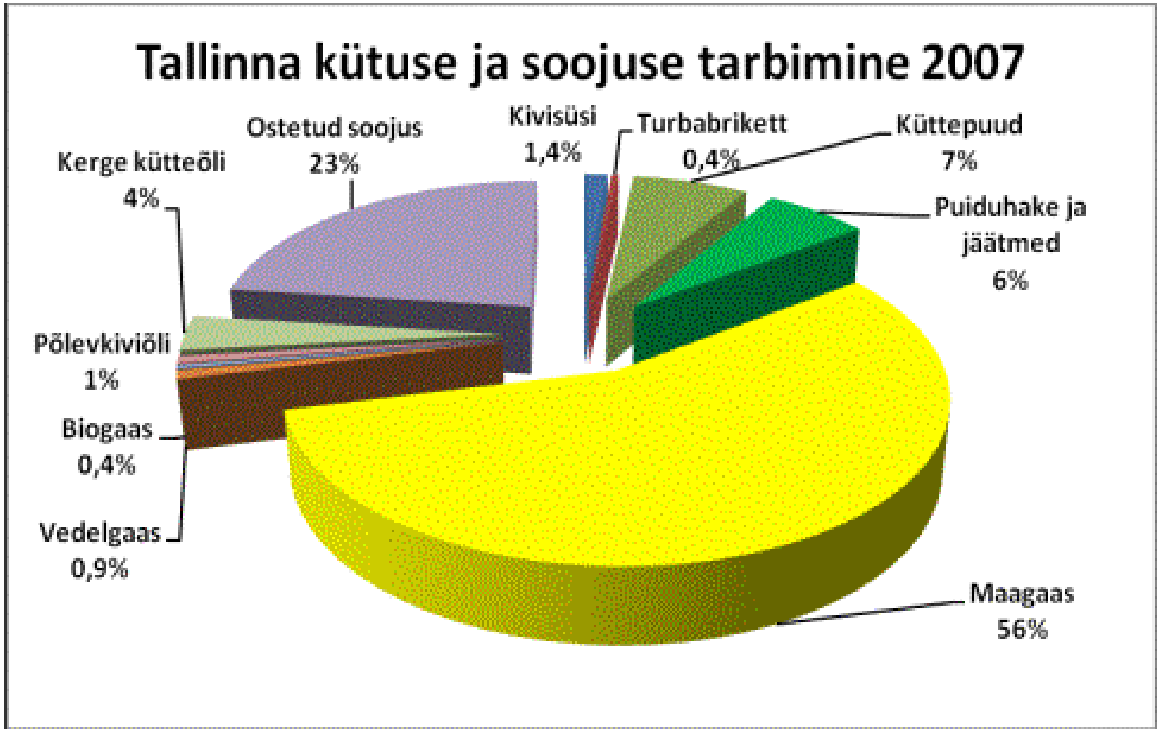

Figure 1. Fuel and purchased heat consumption in Tallinn 2007
[title above the diagram: Fuel and heat consumption in Tallinn 2007. From left to right: Liquid gas, Biogas, Shale oil, Light fuel oil, Purchased heat, Coal, Peat Briquette, Wood fuel, Wood chips and pellet, Natural gas]

The consumed fuel analysis in the present Action Plan is limited to the administered territory of Tallinn. Heating fuel is also imported from outside Tallinn. In 2007, Iru Power Station produced more than half of Tallinn's heating. Heat purchased from Iru Power Station is shown in the fuel and energy balance as purchased energy.

In Tallinn 2007, natural gas consumption comprised the greatest part of all power-generating fuel and covered more than half of Tallinn's fuel balance. A significant part of the fuel balance belongs to AS Tallinna Küte Boiler-houses, and to Iru Power Station, which belongs to AS Eesti Energia. The share of other fuels in the energy balance is less significant in percentage terms.

If we analyse fuel consumption in terms of consumer groups, the biggest share belongs to energy production, or industrial heating. The share of industry and other consumer groups has reduced over the years. The household sector is an important consumer group, as in the suburbs there are still quite a few dwellings with individual heating systems.

The above table shows the data of fuel consumers only. In fact, such ultimate consumers as the general population, commercial and service enterprises comprise a noticeable part of the consumption of power-generating fuel.

The Fuel consumption table shows that total fuel and purchased heat energy consumption amounts to 10.8 MWh for each of Tallinn's residents. These data reflect fuel and heat consumption in Tallinn only. Actual fuel demand for energy generation is much bigger, as the said estimation does not include the amount of actual fuel consumed by Iru Power Station, which would comprise more than the amount of energy produced for heating networks.

2.1.2. Electricity consumption

Most of the electricity is supplied to Tallinn by Elering OÜ, the state-owned independent transmission system operator, so that the production and transmission of electricity can be evaluated as a part of Estonia overall. The smallest share, or 2-3% of electricity, has been produced in Tallinn 2007 in small-scale power stations (BLRT, Pääsküla, Kriistine centre). Iru Power Plant, located on the territory of the City of Maardu, has a significant role in supplying Tallinn with energy. Tallinn's consumers use most of the heat produced in Iru Power Plant. Tallinn's atmosphere is also exposed to the emissions of Iru Power Plant pollutants.

In Estonia, most of the electricity needed (93%) is produced at the Narva Power Plant. Tallinn is supplied with electricity by Elering OÜ’s main network. In order to supply Tallinn with electricity, there are three central electric substations in Harju county which are directly connected to the Narva Power Station: these comprise the reconstructed Harku and Kiisa 330 kV substations and the Aruküla 220 kV substation. Elering OÜ plans to reconstruct the Arukula substation by 2013 and increase its power by up to 330 kV.

Elering OÜ has fourteen 110 kV substations to supply the city of Tallinn with electricity: Power Plant, Endla, Ida, Järve, Kadaka, Kivimäe, Kopli, Lasnamäe, Paljassaare, Ranna, Tõnismäe, Veskimetsa, Volta, and Ülemiste substation. In addition, Tallinn is supplied with electricity by a number of Elering OÜ substations which are located outside the territory of Tallinn, these being Iru, Loo, and Laagri.

Data on the amount of electricity supplied to Tallinn in 2007:

sale of electricity	1994 GWh
maximum load	442 MVA
minimum load	118 MVA
110 kV cable line length	12 km
110 kV aerial cable line length	175 km
110 kV substations	14

0,4–35 kV cable line length	3353 km
0,4–35 kV aerial cable line length	664 km
35 kV regional and distribution substations	167
medium/low-voltage substations	1764

Electricity consumption in Tallinn per capita in comparison with the whole of Estonia, average electricity consumption in the European Union, and with the advanced and neighbouring countries:

Tallinn	5,0 MWh per capita
Estonia	5,1 MWh per capita
EU 27 (all EU states)	5,7 MWh per capita
EU 15 (old EU member states)	7,7 MWh per capita
France	6,7 MWh per capita
Germany	6,4 MWh per capita
Great Britain	5,6 MWh per capita
Finland	16,3 MWh per capita
Sweden	14,6 MWh per capita
Latvia	2,9 MWh per capita
Lithuania	2,6 MWh per capita

The above data for electricity consumption in various places show that electricity consumption in Tallinn is close to Estonia's average electricity consumption level, and is slightly less than the average in the European Union. Electricity consumption in so-called old European Union member states exceeds the average in the European Union by one third. Especially high electricity usage is observed in such northern countries as Finland and Sweden. One possible reason is that electricity in these countries is mainly used for heating and the maintenance of heating systems. Our Western neighbours, Latvia and Lithuania, consume half as much electricity as we do. Probably both Tallinn and all Estonia should use standby power supplies efficiently.

2.1.3. General energy consumption

Considering total primary energy consumption is Estonia-wide: most electricity in Estonia is produced outside the territory of Tallinn, however, all corresponding primary energy costs directly depend on Tallinn's consumption landscape. Though there are no data in regard to energy consumption in Tallinn, the Department of Statistics provides the data of the energy and fuel consumption of those enterprises that have been registered in Tallinn separately from those enterprises that are directly located in Tallinn. The same approach is used in other statistics collection documents, like "Tallinn in numbers."

The review of energy consumption in both Tallinn and the rest of Estonia and its comparison with the neighbouring states is represented in the records of annual energy, incl. electricity, consumption per capita (see table 2 "Energy, incl. electricity consumption").

Table 2. Energy, incl. electricity consumption

State, city, EU	Population (in thousand)	Total Energy consumption (MWh per capita)	Electricity consumption (MWh per capita)
EU 27	495305	41,1	5,7
EU 15	325196	52,3	7,7
Germany	82315	46,5	6,4
France	63626	47,9	6,7
Great Britain	60816	41,0	5,6
Sweden	9117	62,6	14,6
Finland	5277	80,4	16,3
Norway	4800	65,1	23,0
Lithuania	3385	30,5	2,6
Latvia	2231	23,6	2,9
Estonia	1342	50,6	5,1

Tallinn	397		5,0

Energy consumption in this context means total primary energy consumption, including both direct consumption of fuel and fuel used to produce other sorts of energy (electricity and heat), as well as fuel used in the transport sector. It is impossible to represent the total demand for primary energy in Tallinn, as the main part of the electricity used is supplied from outside the territory of Tallinn. Electricity production by modern technical solutions requires three times as much primary energy as the amount of electricity required, so energy consumption in Tallinn is analysed according to the kinds of energy involved: power-generating fuel, electricity, heat, and transport fuel.

The above table of energy demand demonstrates energy consumption in the whole of Europe as well as in Estonia and Tallinn. The table shows energy data (including electricity) for consumption in the European Union (EU 27), in so-called old European Union member states (EU 15), in some large European countries, in Estonia's neighbouring countries, in Estonia, and in Tallinn as well, in comparison to the demand for electricity.

The table illustrates that in both Estonia and in Tallinn as such energy and electricity consumption is at the average level among European countries. Energy consumption in the old European Union member states is higher due to their advanced economies. The northern countries have especially high energy and electricity consumption per capita. The energy consumption in these countries is probably influenced by their cold climatic conditions. The energy consumption of our western neighbours, Latvia and Lithuania, is significantly lower.

If we compare energy consumption indicators, we can accept that with the raising of technical levels, the demand for energy in Estonia, including Tallinn, also has a tendency to rise. However, the rise of energy consumption must be limited by the rational application of technical energy-saving devices. At the same time, the energy consumption indicators of Latvia and Lithuania demonstrate that it is possible to manage with an appreciably lower energy consumption level.

2.2. Heat economy

Tallinn has more than 500 boiler-houses. The list includes both AS Tallinna Küte's large-scale boiler-houses and other consumers' small-scale boiler-houses. The production capacity of Mustamäe, Kadaka, and Ülemiste boiler-houses, all of which belong to AS Tallinna Küte, already exceeds 100 MW. Besides, a number of heat producers (AS Tallinna Küte boiler-house in Spordi St., Fortum Termest AS 100 boiler-houses in Mahla and Kopli St., Dekoil OÜ, AS Tallinna Vesi and Tallinn University of Technology boiler-houses, and BLRT Group AS power and heating plant) work at a production capacity that exceeds 10 MW. More than a hundred boiler-houses work at a production capacity that exceeds 1 MW. The majority of Tallinn's boiler-houses are small-scale ones with a production capacity of up to 1MW, supplying heat to enterprises and dwellings. In 2007, Tallinn's major heat producers were AS Tallinna Küte[4], AS Eraküte,[5] and Fortum Termest AS[6] - these producers supply Tallinn with 70% of the produced heat.

2.2.1. AS Tallinna Küte

AS Tallinna Küte (hereinafter referred to as *Tallinna Küte*) belongs to the Dalkia International SA concern and is the biggest heat producer in Estonia, operating Tallinn's power-and-heat supply boiler-houses and managing Tallinn's urban heating network. In 2007, the number of buildings connected to Tallinna Küte's heating network amounted to 3617, and the number of contractual ultimate consumers amounted to 10 165. Tallinna Küte boiler-houses transmit heat to more than half of Tallinn's heating networks (see table 3 "Tallinna Küte's boiler-houses").

In addition to heat produced in Tallinna Küte as such, the company purchases heat from Iru Power Station,[7] and, since 2009, from the newly established Tallinn Power Station, supplying it to Lasnamae district, Tallinn's City Centre, and the City of Maardu. In 2007, Tallinna Küte purchased 1 120 738 MWh of heat from Iru Power Station, of which 108 736 MWh were transmitted to the City of Maardu, and the rest supplied to Tallinn. In addition, Tallinna Küte purchased 30 891 MWh of heat from other enterprises, mainly Fortum Termest AS boilerhouse (Mahla St. 87), and transmitted it to consumers.

Those Tallinna Küte boiler-houses located in Mustamäe and Kadaka districts supply heat to Tallinn's Western area - Mustamäe, Haabersti, Kristiine, and to northern Tallinn's heat consumers. Today, the Kadaka boiler-house is fully renovated and automated, and its boilers are equipped with modern Low-Nox burners which comply with the European Union directive on environmental requirements for flue gas emissions. The same renovation works are being made at the Mustamäe district boiler-house. The boiler-houses' main fuel is gas. The Mustamäe district boiler-house can use oil fuel as its standby fuel (since 2010 it has been replaced with light fuel oil)

The boiler-house located in Ülemiste district (Masina St. 18) is considered to be a reserve boiler-house; it supplies heat to the City Centre and to Lasnamäe district in case the Iru Power Station stands idle.

Table 3. Tallinna Küte's boiler-houses

Boiler-house	Boiler type	Amount	Actual capacity MW	Fuel	Energy production 2007 MWh/y
Mustamäe	PTVM-100	3	96	Gas/oil fuel	
	PTVM-50	1	50	Gas/oil fuel	
	FW 25-6	1	6	Gas	
	FV 25-8	1	8	Gas	

Total Mustamae boiler-house		**6**	**352**		**392 655**
Kadaka	KVGM-100	2	110	Gas	
	PTVM-50	1	50	Gas	
	FW 26-6	1	6	Gas	
Total Kadaka boiler-house		**4**	**276**		**425 863**
Ülemiste	PTVM-100	2	87	Gas	
	FW 25-8	1	8	Gas	
Total Ülemiste boiler-house		**3**	**182**		**107 258**
Small boiler-houses		**10**	**30**	**Gas**	**30 891**
Total Tallinna Küte		**23**	**840**	**Gas/oil fuel**	**956 667**

In 2007, Tallinna Küte boiler-houses produced 957 GWh (46%) of heat and purchased 1121 GWh (54%) of heat from Iru Power Station (see figure 2 "Tallinna Küte heat supply").

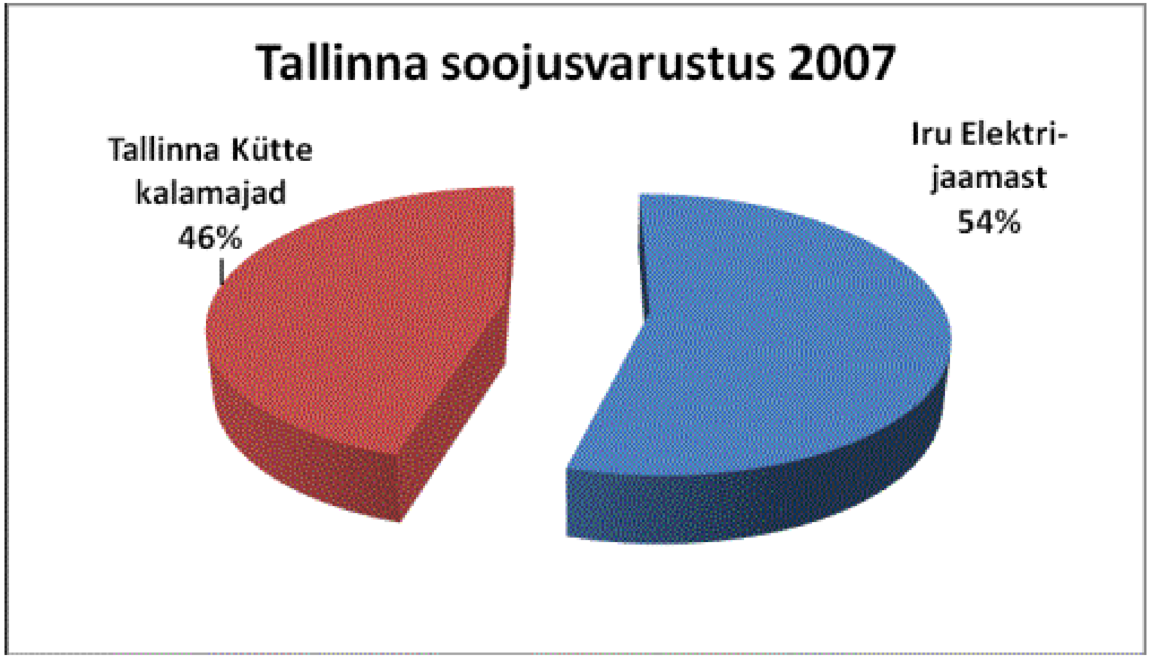

Figure 2. Tallinna Küte heat supply
[Titles from left to right: Tallinn Kute boiler-houses, Iru Power Station]

In 2007, Tallinna Küte sold 1727 GWh of heat, of which 1645 GWh went to Tallinn's urban consumers, and 81 GWh were bought by Maardu city's consumers. Among Tallinn's consumers, 74% of the transmitted heat was sold to residents and 26% to business customers. The use of energy-saving equipment by consumers has reduced Tallinna Küte sales level by 2-5% in the last few years. The district heating network of Tallinna Küte is about 400 kilometres long.
In 2007, Tallinna Küte boiler-houses used 110 million m^3 of natural gas for heat production.

2.2.2. AS Eraküte

AS Eraküte's heating plant (hereinafter referred to as *Eraküte*) also belongs to the Dalkia International SA. concern, and its main office is situated in Tallinn at Punane St. 36, but the majority of its boiler-houses operate outside the territory of Tallinn. Eraküte supplies heat to nine Estonian cities and villages.

Table 4. Eraküte's boiler-houses 2007

Indicators	Unit	Evaluations		
		Total	incl. Tallinn	the rest of Estonia
Boiler-houses' capacity	MW	298	41	258
Produced heat	MWh	450 794	63 291	387 503
Sold heat	MWh	426 764	56898	369866
Fuel for heat generation				
Natural gas	th. m³	22 985	7 580	15 405
Wood chips	m³	268 109		268 109
Shale oil	Ton	8 019		8 019
Milled peat	Ton	4 852		4 852

The biggest Eraküte boiler-houses are located in Tartu, Valga, Jõgeva, Keila, and Haapsalu. Since the main office of the enterprise is in Tallinn, the Department of Statistics collects data on all Eraküte boiler-houses' output and fuel costs in Tallinn. The present Action Plan is based on data collected from the Information technology centre of the Ministry of Environment and from enterprises, covering fuel consumption and heat production in Tallinn only.

In Tallinn 2007, Eraküte owned 25 boiler-houses with a total capacity of 41 MW. Nowadays, the majority of Eraküte's boiler-houses located in Tallinn, are under Tallinna Küte's management. Eraküte's Tallinn boiler-houses use gas as fuel and supply heat to dwellings and some enterprises. The production capacity of their boiler-houses is 0,1–5 MW.

2.2.3. Fortum Termest AS

Fortum Termest AS is that of Estonia's heating plants (hereinafter referred to as *Fortum Termest*) which belongs to the Finnish Fortum OY concern. Like Eraküte, Fortum Termest's main office is situated in Tallinn, but although the majority of its boiler-houses operate outside the territory of Tallinn (Pärnu, Põltsamaa, Vändra, and others), similarly the Department of Statistics collects data on Fortum Termest's output and fuel costs in Tallinn. The present Action Plan is based on data collected from the Information technology centre of the Ministry of Environment and from enterprises, covering fuel consumption and heat production in Tallinn only. (see table 5 "Fortum Termest's boiler-houses 2007").

Table 5. Fortum Termest's boiler-houses 2007

Indicators	Unit	Evaluations		
		Total	incl. Tallinn	the rest of Estonia
Number of boiler-houses	pcs		67	
incl. natural gas	pcs		63	
light fuel oil	pcs		3	
boiler-houses' capacity	MW		132	
incl. natural gas	MW		127	
light fuel oil	MW		5	
Fuel for heat generation				
Natural gas	th m³	59103	19293	39810
Wood chips	Ton	41109		41109
Shale oil	Ton	4272		4272
Light fuel oil	Ton	1541	380	1161
Peat	Ton	10696		10696

Fortum Termest has 67 boiler-houses in Tallinn supplying heat to dwellings and several manufacturing plants (for instance, Tallinn Dairy plant). The biggest boiler-house is located in Mahla Street and its production capacity amounts to 12 MW. The boiler-house uses mainly natural gas.

In the last few years, the number of Fortum Termest's boiler-houses in Tallinn has increased. Fortum Termest took under its control various enterprises' boiler-houses and established new boiler-houses to supply heat to enterprises and dwellings, allowing to close old, less energy-efficient and environmentally unfriendly boiler-houses.

2.2.4. Other heat producers

In addition to the above-mentioned three main heating supply companies, Tallinn is supplied with heat by a number of small-scale companies. Moreover, many production plants and dwellings have their own boiler-houses. Dekoil OÜ, the company that provides transhipment of oil products, and Tallinn University of Technology have their own boiler-houses with a production capacity of more than 10 MW; AS Tallinna Vesi boiler-house and BLRT Group power and heating plants and boiler-houses also work at a total capacity of more than 10 MW.

Heat production in Tallinn is illustrated in the figure 3 "Heat production and purchase in Tallinn 2007." Overall, 3350 GWh of heat were produced in boiler-houses and by private heating. More than 60% of the heat necessary for Tallinn's heating supply is transferred through Tallinna Küte's own heating network. This figure includes both heat produced in Tallinna Küte boiler-houses and that purchased from Iru Power Station.

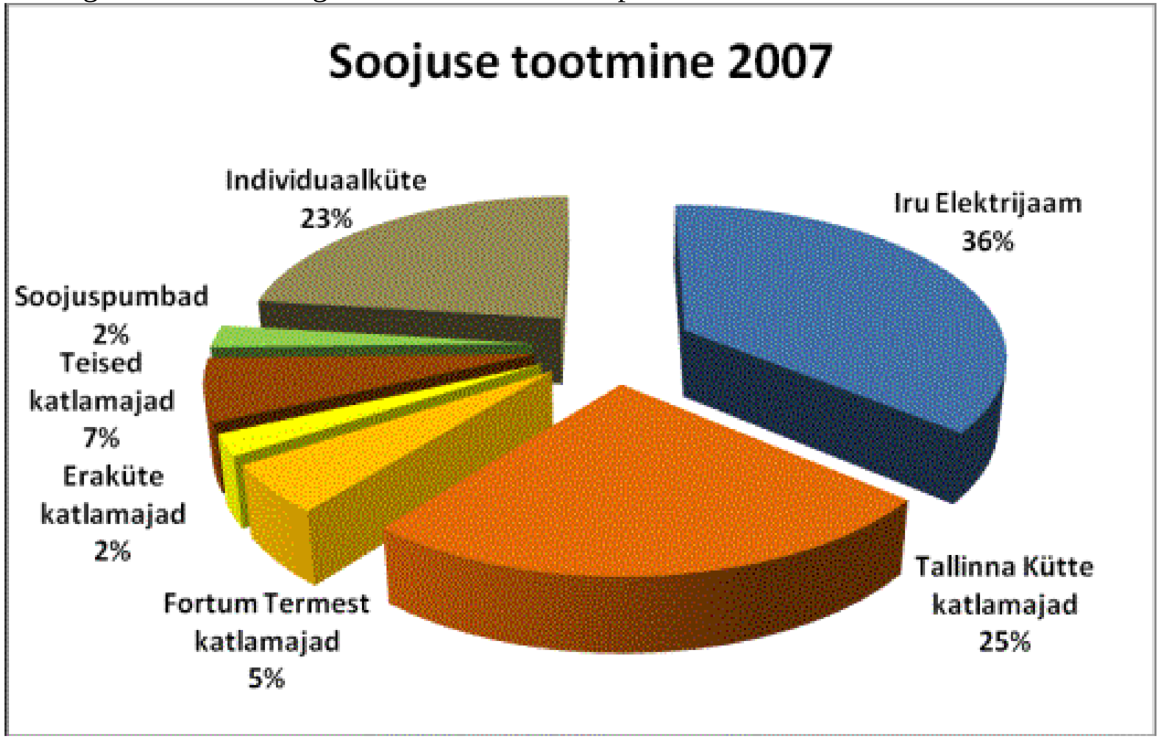

Figure 3. Heat production and purchase in Tallinn 2007

[Title of the diagram: Heat production 2007. From left to right: Fortum Termest's boiler-houses, Eraküte's boiler-houses, Other boiler-houses, Heat pumps, Private heating, Iru Power Plant, Tallinna Küte's boiler-houses].

Fortum Termest' share of the heating supply comprises 5%, and Eraküte boiler-houses' share is 2%. Other enterprises and private boiler-houses produce 7% of the heat. A quarter of the heat needed for Tallinn's heating supply is produced by private heating: boiler-houses in private dwellings and stove heating produce 23%, and the share of heat pumps' is 2%.

In 2007, the heating networks' capacity for electricity and heat generation at cogeneration stations were not fully used. Today, the cogeneration method is used to supply the eastern districts of Tallinn and the City Centre (Tallinn Power Plant). Western Tallinn will use heat produced in central boiler-houses until 2011, when the construction of a new joint heating main is to be completed.

In Tallinn, the cogeneration system has also been applied to separate small-scale energy producers and consumers. The cogeneration system is used in Pääsküla, for bio-gas engines in the sewage treatment plant in Paljassaare, in the heating supply of the enterprise BLRT, in Merirahu district, WTC area, and in Kristiine centre. All these enterprises use gas engines with a capacity of 0,5–2 MW_e. Small-scale power and heating plants provide less than 1% of all Tallinn's heat demand.

Small-scale boiler-houses with a capacity range from several tens of kilowatts to some megawatts have been built to supply heat to production plants, residential areas, and separate dwellings. The main fuel used by these boiler-houses is natural gas.

Small boilers using natural gas supply heat to either whole buildings or to one flat in some newly built terraced and small houses. Old dwellings also have their own private boiler-houses, which are based on light fuel oil or, in some cases, on solid fuel (wood, wood chips, coal). Over the last few years, the use of heat pumps has been increasing: they comprise 2% of the heating supply to new buildings.

Heat consumption by households and enterprises is divided as follows:

- household 2325 GWh 70%
- enterprises 1025 GWh 30%

total 3350 GWh

The division of heat consumption between households and enterprises is based on several sources (statistical data, Tallinna Küte), but still remains a rough estimate. Quite often a building may include offices, shops, and residential flats, so the division of heat consumption between different consumer groups cannot be very accurate.

2.3. Transport and traffic

The major objective of the transport system is to provide all people and enterprises with the ability to reach the places they need. The main function of public transport is to enable residents to travel by both urban and private transport.

Not only is Tallinn is a seaport city with high-density sea traffic, it is also a railway junction, used by the majority of Estonia's railway transports, and has the airport. Air traffic must be considered Estonia-wide, and the volume of fuel consumed for air traffic is not reflected in Tallinn' fuel balance. All types of transport together have a considerable influence on the city's energy balance and pollution level.

2.3.1. Motor vehicles

Over the last decades, the number of vehicles on Tallinn's streets has increased several times over. In Tallinn 2001, there were 175 000 vehicles registered in the Estonian Motor Vehicle Registration Centre. By the end of 2007, the number of vehicles had increased to 251 000, that is, in 7 years time the numberincreased by 76 000, which is 11 000 or 5-6% of vehicles per year on average. Over the last years, the growth in the number of vehicles remained steady.

Probable reasons may include the amendment of calculation methods, the disposal of old vehicles, but also and particularly the general economic situation and the satisfaction of people's needs, that is, nowadays, that each family has a car, and some more than one. Data on the number of vehicles is shown in the table 6 “Number of motor vehicles in Tallinn.”

Table 6. Number of motor vehicles in Tallinn

	1.1.2001	1.1.2002	1.1.2003	1.1.2004	1.1.2005	1.1.2006	1.1.2007	1.1.2008
Motor cars	159 366	134 263	132 874	145 692	156 997	170 133	190712	194136
Buses	1 739	1 747	754	1 760	1 772	1924	2 087	1 952
incl. privately owned			158	160	147	134	134	63
Trucks	2 322	24 410	25 933	28 102	29 824	31 660	35 605	35 796
Motorcycles	1 230	1319	1 386	1 595	1 886	2 056	2 637	3 329
Trailers	10715	10 694	10 988	11 759	12 645	13 401	15 286	15 833
Total	**175 372**	**172 433**	**172 935**	**188 908**	**203 124**	**219 174**	**246 327**	**251 046**

Figure 4 “Number of motor vehicles in Tallinn“ shows the number of motor vehicles in Tallinn.

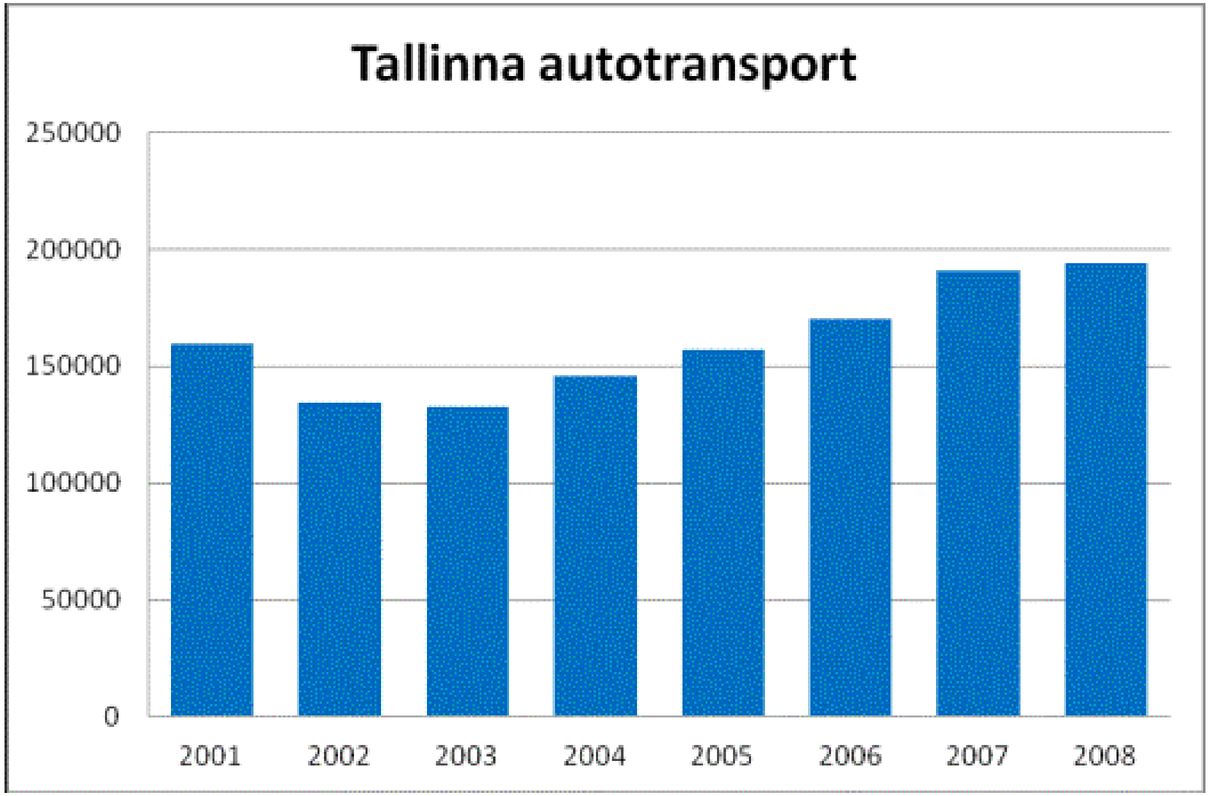

Figure4. Number of motor vehicles in Tallinn

Urban transportation is organised into 56 bus lines, 4 tram lines, and 8 trolley-bus lines, mainly through transport companies owned by the city. During rush hours on working days, 316 buses, 65 trams, and 98 trolleys operate on these lines, or 479 public vehicles in total[8].

In May 2007, Tallinna Autobussikoondis (Tallinn Bus Company Ltd.) owned 213 Scania and 128 Volvo buses, of which 142 were articulated buses, 20 bus-trailers, and 179 ordinary buses.[9]

2.3.2. Railway transport

The total length of railway lines in Estonia is 1026 km, of which 968 km are currently in public use. The public railway network's density is 21,4 km / 1000 km^2. So, among the European Union member states, Estonia is in that group of countries with the smallest railroad network density. The railroad lines are electrified in Tallinn's neighbourhood only. The share of the electrified network comprises only 13,6% of the whole railway network.

Railway lines with 66 railway stations[10] run and diverge from Tallinn's railway junction on three main rail routes. These railway routes are Tallinn-Narva, Tallinn–Paldiski and Tallinn–Viljandi/Pärnu. There are three types of trains in Tallinn: electric and diesel-powered passenger trains and diesel locomotive freight trains. According to the data of the Department of Statistics, in 2007 the number of trains running in Tallinn-Tapa direction amounted to 23 886, of which 12 267 were freight trains and 11 619 were passenger trains. 26 940 trains ran in the Tallinna–Paldiski direction, of which 1911 were freight trains and 25 029 were passenger trains.

2.3.3. Sea traffic

Tallinn Old City Harbour belongs to AS Tallinna Sadam (Port of Tallinn). Tallink, Eckerö Line and Viking Line boats and ferries depart from the Old City Harbour for Helsinki, as well as the Tallink vessels which operate on the Tallinn-Stockholm route. The development plans of the Port of Tallinn envisage the Old City Harbour being converted fully into a passenger port so cargo handling has been gradually moved out from the Old City Harbour and relocated to the Muuga and Paldiski South harbours. TheOld City Harbour covers 52,9 ha, there are 23 berths with a total length of 4,2 km and 4 passenger terminals.

2.3.4. Fuel consumed in the transport sector

Transport fuel is considered to be all the different kinds of fuel used for vehicle engines. The review of fuels used in the transport sector is provided in the table 7 "Fuel consumption in transport sector in Tallinn 2007." In 2007, the total consumption of motor fuel amounted to 301,9 thousand tons, the majority of which comprised diesel fuel and (auto)petrol (see figure 5 "Fuel and purchased heat consumption in Tallinn 2007"), liquid gas was less in use. The Department of Statistics also provides data on light fuel oil consumption in railroad and sea transport.

Table 7. Fuel consumption in transport sector in Tallinn 2007

Fuel	Consumption (thousand tons)	Calorific value of fuel (MWh/h)	Consumption (GWh)	%
Diesel fuel oil	155,6	11,8	1836	50,8
incl. urban transport	8,6	11,8	101	2,8
Petrol	125,8	12,2	1535	42,5
Light fuel oil	20,5	11,8	242	6,7
Liquid gas	0,03	12,7	0	0,0
Total	**301,9**		**3613**	**100,0**

Source: the Department of Statistics; Information technology centre of the Ministry of Environment; Estonian Greenhouse Gas Emissions Inventory Report, 2009.

The share of the road transport sector, or city traffic, in fuel consumption is considerable; it comprises 92% of total fuel consumption in energy units. In Tallinn's city traffic 2007, the amount of petrol consumption was 125 800 tons, and diesel fuel oil consumption was 151 700 tons.

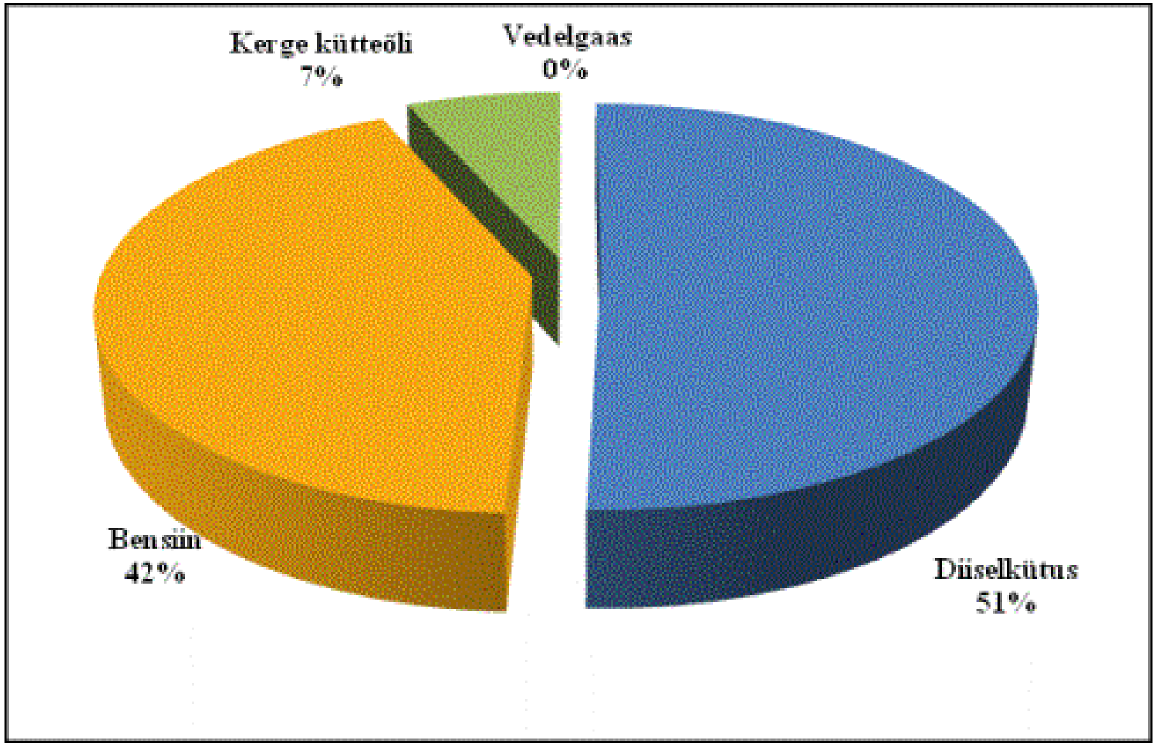

Figure 5. Fuel consumption in Tallinn's transport sector
[From left to right: Petrol, Light Fuel oil, Liquid gas, Diesel fuel oil]

Accurate petrol consumption figures are based on the sales figures of petrol stations located in Tallinn; however it is impossible to obtain the same accurate data for the sales of diesel fuel oil. That is why diesel fuel oil consumption has been estimated on the basis of data from the Department of Statistics and Tallinn's Greenhouse Gas Emissions Inventory Report 2007. Diesel fuel oil consumption can be over-estimated to some degree, as the data from the Department of Statistics on fuel consumption are based on the companies' place of registration. According to data from Tallinn City

Government, the amount of diesel fuel oil consumed by public bus services was 8630 t. The share of these fuel costs in the whole amount of fuel consumed in the city's traffic (in energy measurement units) is 2,8% only.

Motor fuel apart, urban transport (trams, trolleys, and electric trains) also uses electric power. Tram and trolley traffic offers services within the territory of Tallinn. According to data from AS Tallinna Trammi- ja Trollibussikoondis (Tallinn Tram and Trolley Bus Company Ltd.), in 2007, the amount of electric power consumed on the lines was 25,5 GWh. Electric train traffic mainly operates within the territories of Tallinn and Harju County. There are no data on the use of electricity of rolling stock within the territory of Tallinn. The share of urban transport's electricity consumption in total fuel and energy consumption is small (1%).

The share of the known fuel and electricity costs of urban transport in the total transport sector's energy consumption (in energy measurement units) is 3,5% only.

2.4. Street lighting

Street lighting requirements are prescribed by Tallinn City Government's decree nr 26 of March 24, 2004 "Street lighting standards of the city of Tallinn."[11] Tallinn's street lighting situation is analysed by resolution nr 330 "Guidelines for the city of Tallinn’s outdoor lighting for the period from 2006 to 2015"[12] adopted by Tallinn City Council of November 16, 2006. This resolution provides a review of Tallinn's outdoor lighting situation and prescribes clear guidelines for its improvement in the coming years.

The streets of Tallinn started to be lit regularly since 1787, at first with gas lighting. A transition to electric lighting began in 1913, when the Tallinn Electrical Central Station was put into operation. Over the course of years inefficient incandescent lamps used for street lighting were replaced with energy saving sodium lamps.

Tallinn's street electrical network as of January 1, 2007.

Total outdoor sources of light	45 660
incl. street lighting	39 000
Total production capacity of outdoor sources of light	8500 kW
incl. street lighting	7500 kW
Energy demand of outdoor sources of light	34 000 MWh
incl. street lighting	30 000 MWh
Total length of illuminated streets and roads	1728 km
Total length of street lighting network cable lines	1496 km

incl. aerial lines with noninsulated wire	206 km
aerial cable lines	582 km
underground cables	708 km
The number of switching-distribution boards	516

The rapid development of energy-saving street lighting began in 1994, when the municipality installed high-pressure sodium lamps instead of old mercury lamps. Prior to 1997, the increase in new sources of lighting was negligible. Beginning from 2001, 2000-3000 lamps were added annually. In 2009, the number of sources of lighting reached 51 000.

Upon the implementation of energy-saving sources of light, the electricity demand for street lighting has risen to a small extent. The majority of the old sources of light were replaced with new ones in 2001, and there has been a remarkable improvement in the safety of sources of light, as well as in lighting and technical performance.

The condition of street lighting is generally satisfactory, as, beginning from 1999, the municipality began to implement the recommendations of the International Electro-technical Commission, and they are valid in the current EVS-EN 13201 standard. Problems occur in those areas of road lighting where the lamps are located on the same lamp post as Eesti Energia Jaotusvõrk OÜ's (Distribution Network) electric lines: lamp posts are located too far away from each other and the lamps are hidden by high trees and bushes.

There are also problems related to a bad level of current aerial line insulation at the contact lines of electric transport. Contact lines are required to be double insulated in order to avoid stray current crossover in the lighting network of the transport lines. Stray currents may cause the overall burnout of lamps in some areas.

Over the last years, for the improvement of road safety, much attention has been paid to the installation of lighting at those pedestrian crossings that are not regulated by traffic lights. In the period from 2005 to 2010, in Tallinn, 216 pedestrian crossings were fitted with 434 lights in total, which accounts for more than half of the city's pedestrian crossings not regulated by traffic lights. These works are going to be carried on with in the following years.

The sources of light commonly used in the street lighting, are the following:

- ***low pressure sodium lamps*** – energy-efficient, however, they are not completely suitable for road lighting in the city because they send out monochrome yellow light, which militates against colour discrimination; the colour rendering index is 0, and these lamps are not used in Tallinn;
- ***high pressure sodium lamps*** – energy-efficient, average lifetime is four years, these lamps are commonly used for road lighting, colour rendering index is 20, colour temperature is 2000 Kelvin degrees (with a yellow light);

- ***high pressure mercury lamps*** – their light output is more than half that of high pressure sodium lamps, the average lifetime of mercury lamps is three years, colour rendering index is 40-60, colour temperature is 4000 Kelvin degrees (with a cold white light);
- ***metal halide lamps*** – their light output is 15% less than that of high pressure sodium lamps, the lifetime is three years, they have excellent colour rendering index (80-90), colour temperature depending on the type of lamp varies from 2800 (warm white light) to 4500 Kelvin degrees (cold white light). The price of metal halide lamps is much higher in comparison with the above-mentioned lamps, and the capacity of 2800 Kelvin degrees lamps is relatively low.

High pressure sodium lamps are mostly used in Tallinn's street lighting. These sources of light in comparison with other alternatives are energy-efficient, have a longer lifetime, sufficient light quality, and relatively low price.

2.5. Water industry

Tallinn's water supply enterprises are divided into ten areas. Tallinn's biggest water supply enterprise is AS Tallinna Vesi (Tallinn Water Ltd., hereinafter referred to as Tallinna Vesi) Moreover, Tallinn has three small-scale area water supply enterprises. Small-scale water supply enterprises take wastewater to Tallinna Vesi's disposal line. Tallinna Vesi also renders services to a number of Tallinn's neighbouring areas, such as Saku, Maardu, and Viimsi. All data on Tallinna Vesi's business activity and development programmes are presented in the annual reports. The present Action Plan is based on this data for the year 2007.

Tallinna Vesi has two water treatment centres, Ülemiste water treatment plant and Paljassaare Sewage treatment plant. In addition there are a number of groundwater wells and pumping stations supplying the city with water. Groundwater wells are mainly situated in the Nõmme and Pirita districts. The main objective of the water industry is to provide qualitative preparation of water and wastewater treatment. Tallinna Vesi's main activity is water and wastewater treatment, the maintenance of networks, and the effective management of pumping stations. These activities require the use of the biggest amount of energy in the water industry. Most of the energy goes on water and wastewater treatment, as well as on the maintenance of the networks' pumps.

Total consumption of electric power has remained steady over a number of years. The electricity costs of the Ülemiste water treatment plant have decreased, while the electricity costs of Paljassaare Sewage treatment plant have increased. Improved wastewater treatment technology has led to some increase in energy consumption.

Consumed electric power (2007)

- Water treatment plant 10 389 MWh
- Sewage treatment plant 19 443 MWh
- Networks' pumps 5589 MWh

- Other equipment 995 MWh
- ➢ Total 36 416 MWh

Most energy is spent on the production of ozone. Ozone water treatment is very efficient in the destruction and cleansing of the organic matters that are contained in water. This equipment has to operate day and night in order to satisfy the necessary needs of consumers'.

The brand new purification technology which has increased energy demand for wastewater treatment has started to reduce and stabilise electricity consumption per purified wastewater measurement unit. This demonstrates that the whole process contributes to the total improvement in the energy conservation level.

- Purified wastewater electricity consumption per thousand m^3 0,42 kWh/m^3
- Electricity consumption in water treatment plants' water production per thousand m^3 0,45 kWh/m^3

Paljassaare sewage treatment plant's sludge-digestion chambers extracts biogas. Overall 2,5 mln m^3 of biogas were produced in 2007. Biogas is used in gas engines used start up the turbine to supply the aerotank with air and the boiler with fuel. The remaining biogas is burnt in so-called candles (the use of biogas is illustrated in the figure 6 "The use of biogas in Tallinna Vesi sewage treatment plants"). Biogas that had been burnt in gas engine is deemed to be electric power. In 2007, 1159 MWh of electricity were produced from biogas, which amounts to 6% of electricity consumption in the sewage treatment plant and 3% of the electricity consumed by Tallinna Vesi in total.

At the same time, 19% of biogas has been burnt in the candles, so 452 thousand m^3 of biogas remained unused. Supposing that the average calorific value of biogas is 6 MWh / 1000 m^3, then 2,7 million kWh of energy has remained unused. This amount could be used to produce the same quantity of electricity as one gas engine. In November 2009 the gas engine was put under maintenance for at least two months, and the remaining biogas from the boiler was burnt in the candle. In order to increase the efficiency of the use of biogas for electricity and heat production, a second gas engine must be installed at the sewage treatment plant.

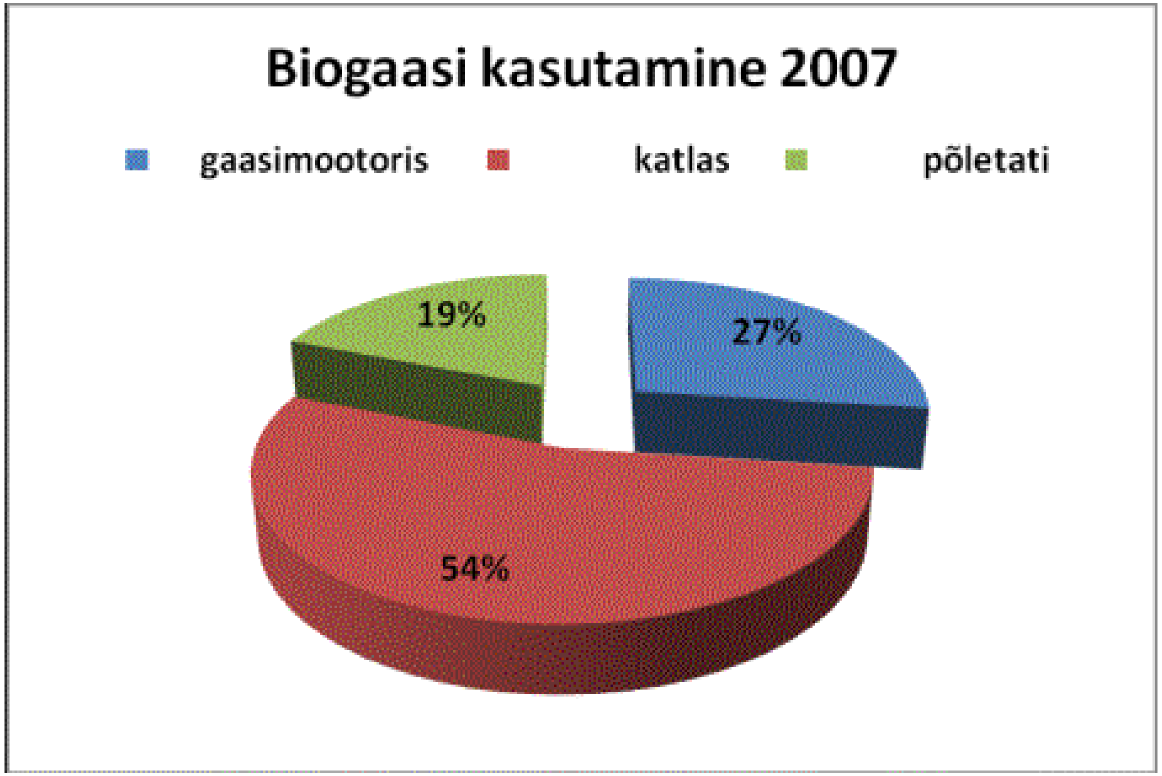

Figure 6. The use of biogas in Tallinna Vesi's sewage treatment plants
[From left to right: in gas engines, in boilers, burnt]

Other energy costs also include transport. There are 140 vehicles used by employees as well as station wagons and private vehicles, that is why it is quite difficult to find opportunities to reduce fuel consumption to any great extent. Attempts are being made to control car drivers' fuel consumption by setting certain limits, however, increasing water consumption has caused the extension of the area serviced, so the extent of the maintenance works has also risen, causing an in the need of moving from one place to another.

Consumed fuel (2007)

- Petrol 135 251 litres
- Diesel fuel oil 210 827 litres

Energy could also be saved by the elimination of any spillages. In 2007 the level of spillages had already fallen up to 19%; the target to be achieved is up to 17-18%. The time spent on the elimination of spillages has also decreased: in 2006, it amounted to 2,2 days, in 2007 it amounted to 1,8 days.

2.6. Waste management

Waste management norms and standards are prescribed by four acts: the Waste Act[13], the Packaging Act[14], the Environmental Supervision[15] Act, and the Environment Charges[16] Act.

Tallinn's waste management regulation stipulates the obligations of holders of waste and waste management officers in order to protect the environment on the city's waste management territory. The regulation also prescribes that waste management shall be organised and supervised by Tallinn's Ministry of Environment and by Tallinn's district governments. Thus, Tallinn's Ministry of Environment and Tallinn's district governments play a significant role in the process of waste management in Tallinn, since their duties are the following: regulation of waste management development in their respective territories, development of systems for collection and sorting of waste materials, support of development programmes for waste energy consumption, waste stream management, and others.

Organised waste transportation is an important factor from the point of view of waste management.

The Waste Management officer is the primary link in the chain of statistical data collection on waste management; this officer submits waste management reports to the Harju County Environmental Service of the Ministry of Environment. These reports are transferred to the Information technology centre of the Ministry of Environment, which analyses the received data and makes the appropriate waste statistics. These reports reflect data on all enterprises having a waste licence and on those that accumulate a considerable volume of waste.

Landfill[17] for Tallinn was established on the 2nd of June 2003 in the old Maardu quarries of Jõelähtme Parish, which fulfil all the environmental requirements of the European Union. The landfill has three drainage areas (total area is 5,1 ha) and waste collection area (total area of the landfill is 67 ha). Nowadays, it is the largest landfill in Estonia, managing more than one third of the household waste in the country. Tallinn landfill's main areas of activity include waste management and storage, composting of bio-decomposed waste, sorting, and alternative energy production.

Reusable waste materials are sorted into different classes, mainly metal and wood waste materials. At the beginning of 2008, Tallinna Prügila AS (Tallinn Landfill Ltd) built the infrastructure along with a composting station and waste collection area on the territory of the landfill, which comprised 8,35 ha in total. In 2010, a waste sorting line and waste fuel production line were installed on the territory of the landfill, intended to take in 40,000 tons of waste per year.

Tallinn's landfill will manage the waste of Tallinn and its surroundings (which comprises up to 500 000 residents) for the next 40 years, by the end of which the project will come to an end. The following 20 years will be used for the closing of the landfill, collection of the gas from the landfill, and monitoring.

In Tallinn 2007, a total of 243 635 tons of waste was stored in the landfill, of which 206 146 were stored in Tallinn's landfill, 36 001 tons were transferred to OÜ Slops construction waste landfill, and 1488 tons of waste were stored in Oru landfill. The total amount of stored mixed household waste amounted to 192 600 tons, and the total amount of construction waste was 50 900 tons. Reusable packaging waste in Tallinn totalled 19 800 tons.

It is not reasonable to store bio-decomposed waste in the landfill, since it can be processed either by aerobic (composting) or anaerobic (methane fermentation) waste treatment. Composting of separately collected bio-decomposed waste generates a good quality compost which can be successfully used in the gardening and agriculture fields. Mixed waste stabilisation produces material which is quite suitable for landscaping and landfill covering.

In Tallinn's landfill, aerobic composting is being operated along with the membrane composting system. Compost piles are covered with a membrane which insulates the piles from environmental influences (reduces the ingress of rainwater into the compost materials, the impact of temperature, as well as eliminating bad smells, and prevents birds from spreading the composted waste). Control over the composting regime is automatically operated. Compost piles undergo an aeration procedure which accelerates the whole composting process.

Anaerobic digestion is an alternative biological treatment of organic waste. The gas which is produced through biological digestion can be collected. The solid product is similar to the composting material, but, depending on the type of raw material, the ultimate product may require secondary treatment before being ready for use.

Paljassaare Sewage treatment plant's sludge-digestion chambers release biogas. Overall 2.5 millon m^3 of biogas were produced in 2007. Biogas is used in the gas engines which start up the turbine to supply the aerotank with air and the boiler with fuel.

A small proportion of mixed household waste, separated from the waste type that can be further recycled, suits anaerobic digestion perfectly. Besides, sludge that remains from wastewater purification, - either separately or together with the above waste materials, - can be put through anaerobic digestion to produce methane, which can then be used in energy generation. In Tallinn, anaerobic processing of wastewater sludge is used in the wastewater purification procedure.

The profitability of waste anaerobic treatment depends on the opportunities to use the energy that remains after the whole treatment. If there is no demand for biogas, the efficiency of anaerobic way of waste treatment cannot be justified since this procedure requires a lot of investment.

The Pääsküla landfill was closed in 2003. Nowadays, waste treatment plant has been opened next to the old landfill, sorting and storing various waste materials. Biogas is being collected from the closed landfill, the production of which began in 1993. In the beginning, biogas had been used as a boiler fuel only, but since 2001 it has also been used in gas engines for electricity generation. Nowadays, biogas is used in two gas engines at the Pääsküla closed landfill, and the remaining gas, if any, goes to the boiler house. Over recent years the volume of biogas has decreased. In 2007, the landfill's gas engines produced 12,4GWh of electricity and 9,6 GWh of heat from biogas.

Tallinn's Paljassaare Sewage treatment plant uses anaerobic sludge digestion, and the secondary treatment of materials is made in the compost area. In the compost area, soil is generated from wastewater sludge, which is then used in the city's landscaping and sold to private consumers.

In order to fulfil commitments to the European Union in regard to waste treatment procedures and to develop environmentally friendly and optimised waste treatment systems, which would be applicable over the whole territory of Estonia, the state has worked out projects for the period from 2008 to 2013 that prescribe waste treatment scenarios.

2.6.1. The composition of household waste

The state's waste treatment programme provides for the evaluation the composition of household wastes', based on data from the packaging and waste registry as well as the evaluations of waste management officers. The average chemical composition of household waste in Estonia is shown in table 8 "Chemical composition of household waste and heating value"

Table 8. Chemical composition of household waste and heating value

Composition of waste fuel substance	Mass percent
- Carbon (C)	26,4
- Hydrogen (H)	3,7
- Sulphur (S)	0,20
- Chlorine (Cl)	0,3
- Ash content (A^t)	21,1
- Water content (W^t)	30
The lowest heating value of waste fuel:	
- waste fuel consumption substance (Q^t_a),	10,5 MJ/kg
- waste fuel dry substance (Q^k_a),	16,1 MJ/kg

The minimum and maximum variation of chemical substances' contents in wastes is relatively high. The heating value of wastes depends on the composition and water content of wastes that are supposed to be used as fuel. The lowest heating value of household wastes is usually 8–12 MJ/kg, depending on the content of combustible materials (mainly these are carbon and hydrogen).

According to the estimates of the Estonian Institute for Sustainable Development, the percentage of bio-decomposible waste in all household wastes is 65%, and the total of combustible wastes along with bio-decomposible waste in all household wastes is 80%. The development of waste recycling makes it possible to change the composition of waste together with the heating value of those wastes that are intended for incineration.

The average composition of mixed household waste in Estonia is illustrated in the figure 1 "Fuel and purchased heat consumption in Tallinn 2007."

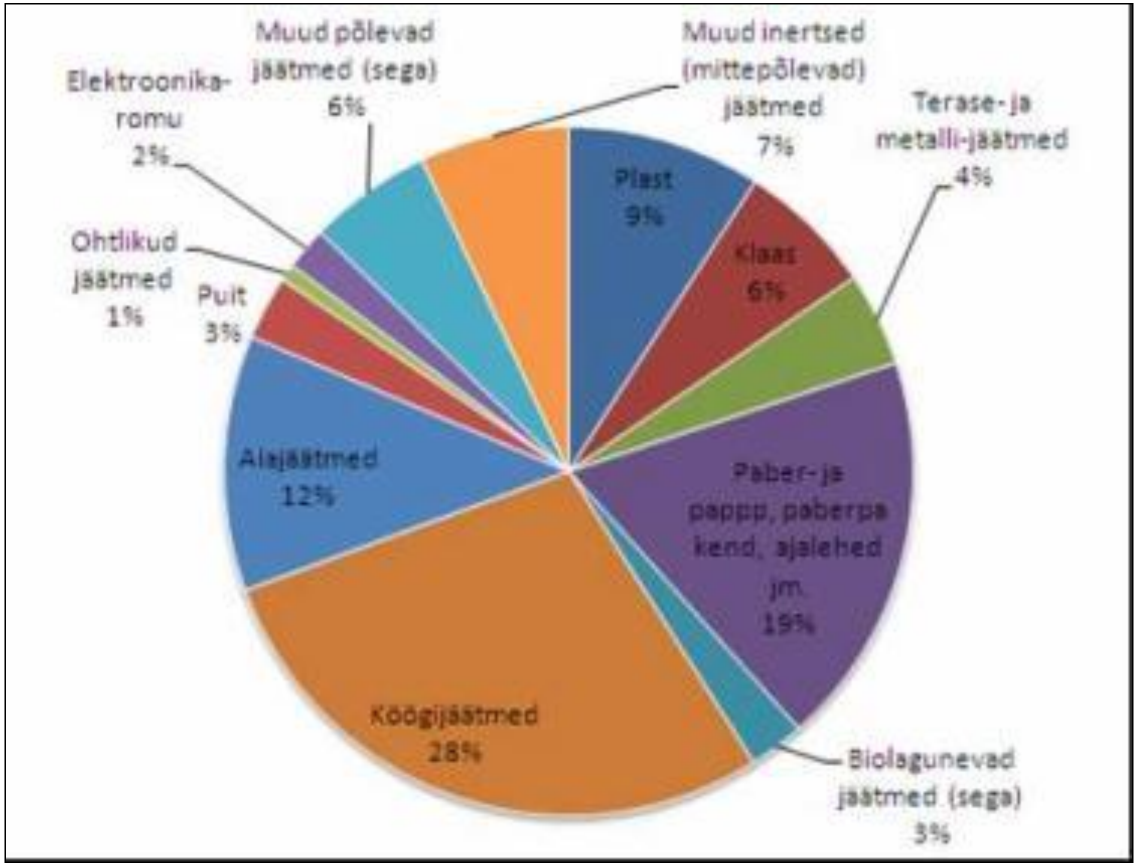

Figure 7. The average composition of mixed household waste in Estonia
[Titles inside the diagram from left to right: kitchen waste; garden waste; plastics; glass; paper and cardboard, paper wrapper, newspapers, and others. Titles outside the diagram from left to right: hazardous wastes, electronic waste, other combustible waste (mixed), other inert (non-combustible) wastes, steel and metal waste, bio-decomposed wastes (mixed)].

Nowadays most waste is stored in landfill. It makes sense to sort waste in advance, to compost bio-decomposible waste, to incinerate organic waste, and to store only non-combustible waste.

2.7. House building

As of January 1, 2007, Tallinn's housing stock amounted to 10 285 000 m², of which approximately 2/3 comprised apartment dwellings and 1/3 belonged to small dwellings. The average age of big apartment blocks with load-bearing wall construction is 25-30 years, the average age of small dwellings is more than 50 years. The average age of other apartment houses varies a lot: the age of wooden houses in old residential areas is up to 100 years.

The average lifetime of a dwelling is deemed to be 50-70 years, so a noteworthy share of our housing stock has reached this lifetime peak or is about to reach it. The construction and technical systems of those dwellings that have already reached their lifetime peak are considered to be outdated both physically and morally, so in addition to continuous maintenance work, these buildings require substantial reconstruction. The period of industrialisation of the construction industry began in 1950-1960, and was followed by mass production and the use of concrete steel structures. The quantity of buildings was considered more important than the quality of construction, and energy prices were low.

Those apartment dwellings and technical systems equipped with central control panels which had been constructed according to the City Council's standards, and from the materials current at that time, spend an incredible amount of energy from the point of view of modern concepts. With reference to the energy audit and marking which have been carried out in Tallinn's apartment dwellings, it can be stated that the range of the average energy costs is 250–300 kWh/m² per year, which exceeds the average performance of the developed industrial countries with the same climatic conditions by a third.

Reinforced concrete slabs comprise a remarkable share of Tallinn's building wall construction. These slabs have good heat insulation, which is, however, insufficient and not evenly distributed. Besides, cold bridges may occur due to gaps in the thermal insulation barrier. According to the estimates of scientists from Tallinn University of Technology, the thermal conductivity of reinforced concrete slabs is 0,5–0,6 W/m^{2}K[18]. If we add heat losses as a result of cold bridges, then the thermal conductivity of walls in apartment houses with bearing-wall construction will amount to 1,0–1,2 W/m^{2}K. The thermal resistance of new reinforced concrete slabs is not satisfactory either,- 0,3–0,4 W/m^{2}K. According to Estonian construction norms, the thermal conductivity of a new building's walls can be a maximum of 0,25 W/m^{2}K.

The energy demand for heating in buildings with reinforced concrete slabs is therefore high. These buildings require heat insulation to be 100-200 mm thick, so the percentage of fully renovated and heat-insulated dwellings in Tallinn is quite small.

The common drawbacks of apartment blocks with reinforced concrete slabs are the following:

- low thermal resistance and insufficient wind-loading rating of outside constructions (walls, doors, windows, roof, attic ceiling, roof-ceiling, cellar walls, and ceiling);
- cold bridges (a cold bridge occurs in the inner structure of buildings, when materials with high thermal conductivity (concrete or steel) create pathways for heat loss that bypass the thermal insulation of adjacent materials either partly or fully);
- some building still have heat supply stations equipped with poor automatic controls: in most cases there is no automatic control system of the temperature of water heating; the hydraulic circuit of a heat supply station usually causes overheating in spring or autumn, when outside air

temperature is relatively high (in this case it is impossible to reduce the level of the heating water temperature in boiler houses, otherwise there will be no guarantee that the household water reaches the necessary temperature);

- poor automatisation of heating systems - generally, there is no regulation system, eg. in a heated room;
- the heating system is mainly built as joint piping system, which means series connection of radiators to individual heating risers. This system is poorly regulated: in most cases residents had rebuilt their heating system without permission (increased the radiators' effective area), which exacerbated existing problems with the regulation system;
- often, heating systems cannot be balanced, which basically means that some apartments or areas are overheated, while the others get insufficient amounts of heat. Both overheated and under-heated conditions often occur in different parts of the heating riser - apartments that are located far from the building's heat supply station may get an insufficient amount of heat in comparison with those apartments that are overheated due to their close proximity to the heat supply station (distribution pipes);
- it is impossible to isolate heating from ventilation air with the use of current air circulation systems (in a kitchen or a bathroom) using either natural or artificial ventilation.

Residents of these dwellings consume too much energy and accordingly pay a lot of money. If the price of energy systems keeps growing, then certain measures have to be taken to change the energy demand of dwellings, their technical condition, and the living environment of residents, such as the inside environment of buildings, which will contribute to extending the lifetime of buildings and to a significant improvement in their external appearance.

So special attention must be paid to the preservation of existing buildings: energy-saving renovation measures, extension of the lifetime period, and measures to increase the value buildings.

2.8. Elements of urban design

Elements of urban design include memorials, monuments, the Old town, parks, and promenades; energy demand is closely related to their lighting. It is difficult to differentiate between street lighting and the lighting of elements of urban design, which anyway are supplied with electricity by one and the same power unit and, in any case they supplement each other.

Over the last years, considerable development has indeed taken place in the field of lighting of elements of urban design. While in Tallinn 1997, there were 28 400 in total of outside sources of light, of which 1400 were supposed to illuminate the elements of urban design, in 2007, their total amount reached 45 600, of which 7000 illuminated the elements of urban design. At the same time, while the total number of outside sources of light has increased 1.6 times, the number illuminating elements of urban design has increased fivefold.

The gross power of sources of light that illuminate elements of urban design can be estimated at 1,0 MW, and 4 Gwh of electricity is spent on this lighting annually.

2.8.1. Park lighting

The most remarkable development has been observed in the field of park lighting in this century. If 10 years ago parks were poorly illuminated, then, nowadays, Tallinn's parks are being illuminated at night hours more. Today, there are a lot of alternatives for park lighting. A number of solutions is used to create a visual effect and achieve an appropriate level of lighting. Local architecture and the creation of plant growth conditions must be taken into consideration. The main lighting alternatives include full illumination, contour illumination, lunar illumination, light reflection, and shadowing.
High pressure mercury lamps are commonly used in park lighting; these consume quite a lot of energy, however they provide pleasant light and good colour discrimination. The high pressure sodium lamps which are common in street lighting are not suitable for park lighting due to their poor colour discrimination, especially, of green.

2.8.2. Lighting of the Old town

The Old town is one of the most treasured districts in Tallinn, that is why the city's major task is to provide it with excellent lighting. The cable network in the Old town is degraded in some areas and lots of lights are technically ineffective.

The Old town is illuminated mainly by 250W high pressure sodium lamps which have no reflectors and are therefore quite inefficient. According to estimates, the overall illumination of the Old town is generally good since the quantity of illumination is relatively high and there are no poorly lit streets.

There are problems with the lighting solutions of some buildings' front elevations, however most of these buildings are privately owned. Somewhere buildings are either over- or under-illuminated, while in other places unsuitable lights are in abundance. It is necessary to co-ordinate ambient sources of light with those of buildings' front elevations by each street in the Old town, and to continue the development of the existing illumination solutions.

2.8.3. Monuments and memorials

All important Tallinn memorials and monuments are separately illuminated in addition to the lighting coming from street lights, so it is impossible to make calculations for the electricity demand of memorial lighting only. Memorials are separately illuminated by both lamp-post lights and by floodlighting. The illumination is designed to emphasise the value of memorials.

2.8.4. Promenades and easy way roads

Promenades and pathways, as well as their lighting, have gone through rapid development over the last decade. Here, it is also difficult to differentiate the lighting of streets and pathways. For example, pathways in the Nõmme and Haabersti districts have been built in a manner that does not require separate illumination as they are perfectly lighted by the normal street lighting. Pathways in the Pirita district are tens of metres away from the roadway and equipped with separate lights.
Promenades require special treatment. Nõmme[19] and Pirita[20] exercise- and skiing roads are the longest and the most advanced in the city. Nõmme promenade along with the part of the Harku forest on the Harju County territory is 15 km long, and the electric power of its illumination is 50kW. Tallinn supplies the whole pathway with the necessary amount of electricity and, therefore it has to be treated as Tallinn's facility.

The second longest exercise- and skiing road is the 7,2 km long Pirita district road. The energy demand of this pathway is not that great since its lighting power is 20 kW. Basically, the pathway is equipped with 70W high pressure sodium lights that are located 20-30 metres from each other. The pathway's lights operate in the evening hours from sunset until 11p.m. and in the morning hours from 6 a.m. until sunrise.

2.9. Use of land

The area of Tallinn is 159 km^2 and is divided into eight administrative districts: Haabersti, Kesklinn, Kristiine, Lasnamäe, Mustamäe, Nõmme, Pirita, and Põhja-Tallinn. The population density of Tallinn is 2510 residents per square kilometre, which is approximately 81 times as much as the average population density in Estonia.

The residential area has the biggest share of the whole territory of Tallinn (27.8%), which is followed by the public area (20.2%). The proportion of the transport area (13.3%) and industrial area (11.7%) is almost equal. Other areas occupy less than 10% of the whole territory.

Table 9 "The territory of Tallinn, the city's districts and the population" show the data on Tallinn's districts and population as of January 1, 2008. The territory of Tallinn also includes Aegna island, Ülemiste lake, and Harku lake; the first two of these belong to the City Centre's territory, while the last one is included in Haabersti district. This fact significantly distorts the comparison of the city's districts.

Table 9. The territory of Tallinn, the city's districts and the population

The city's district	Population		Area		Population density (res/km²)
	Number of residents	%	km^2	%	
Haabersti	39 587	9,9	22,2	13,9	1786
Kesklinn	47 671	11,9	30,6	19,2	1557
Kristiine	29 478	7,3	7,9	4,9	3746
Lasnamäe	112 001	27,9	27,4	17,2	4086
Mustamäe	64 243	16,0	8,2	5,1	7883
Nõmme	38 725	9,6	29,2	18,3	1328
Pirita	14 039	3,5	18,7	11,7	751
Põhja-Tallinn	55 628	13,9	15,2	9,5	3669
Tallinn in total	401 372	100,0	159,2	100,0	2521

A rRelatively dense population is observed in Tallinn's largest residential areas, such as Mustamäe, Lasnamäe, and Kristiine, with a prevalent number of multi-storey apartment houses of bearing-wall construction enabling the use of district heat supply systems. Besides, in the areas with dense population, heat losses comprise an insignificant share of the whole.

The District Heating Act stipulates a clear specification of Tallinn's areas with district heat supply systems. Besides, areas with district heat supply systems[21] have been specified in accordance with the recommendations of scientists from Tallinn University of Technology, stating that it is reasonable to install district heat supply in the areas with dense population. The projection of heat supply systems in the new residential areas has to be based on the assumption that the consumers' load must be at least 2 kW/m of pipeline per one metre and the installed load must be at least 40 kW in each supplementary heating network.

Tallinn's Nõmme and Pirita residential areas, where mainly private houses and small apartment houses are surrounded by green fields, have a lesser population density. Dwellings in these districts are mostly heated individually. However dwellings with a higher population density are heated by local heating, local boiler houses, and heating networks. These methods are common for those areas where natural gas can be used. Heat pumps and solar heating panels have become widely used in private houses.

2.9.1. Green field areas

The green field area comprises 27.3% of the whole territory of Tallinn[22]. The biggest share of this green field area is in Mustamäe district (43.7%), the smallest share belongs to Kristiine district (9.0%). The share of green field area in such districts as Lasnamäe (12.7%), Haabersti (22.6%), and Põhja-Tallinn (12.4%) is also below the city's average level.

Tallinn's forests cover 24.9 km^2 of the territory and comprise 57.6% of the whole city's green field area. Timber stands comprise approximately the same share as the whole biomass on the city's territory. The biggest timber stands are on Aegna island, in Nõmme district, in the neighbourhood of Ülemiste lake, Pirita district (Kloostrimets (Monastery) forest), Pirita river valley, and in Haabersti district (Stroomi forest, Rocca al Mare).

Greenfield areas are actively used to create leisure areas for Tallinn's residents. Thus, for instance, a 15km long illuminated promenade has been built on Mustamäe slope and in Harku park forest; the 8km long pathway in Pirita district must also be mentioned in this respect. In winter, there are organised illuminated skiing pathways with artificial snow.

2.9.2. Use of transport area[23]

The total area of Tallinn's roads is 10 500 000 m^2 and their length 956 km. The total area of the pedestrian paths is 2 278 000 m^2 and their length 852 km. In Tallinn, there are 892 roads and streets in total. In the course of the last decade, new roads have been built due to the construction of new dwellings and the development of new projects, for instance, the widening of passages or highways. The total area used for car parking has significantly increased, being related to the development of shopping centres or other recreational areas.

As of April 1, 2007, there were 8400 fee-paying parking spaces inside the designed parking areas and 5600 fee-paying parking spaces outside parking areas. Car parking has significantly changed the use of space, eg. backyards and gardens in a number of houses have been fully or partly changed into parking spaces, resulting in the reduction of open spaces and the quality of green field areas.

Some parts of the city, especially the territory of the City Centre and Põhja-Tallinn district, are occupied by harbours, railways, their storage areas, and other transport facilities.

2.9.3. Absorption of CO_2 emissions in Tallinn[24]

Green field areas comprises 27% of the whole territory of Tallinn, of which 24.9 km^2 are covered with forests, comprising 57.6% of the whole city's green field area. The estimation of pollution levels has been based on the assumption that the age of 40% of Tallinn's trees is less than 20 years and the remaining are older, so trees of less than 20 years age cover an area of 996ha.

In 2007, absorption of CO_2 emissions comprised 895.4 tons. Considering that the green field area covers a small part of the city' whole territory, the absorption capacity is correspondingly low. The method of CO_2 absorption and calculation steps are shown in the report "Tallinn's CO_2 Gas Emissions Inventory."

2.10. Consumption habits

Consumption habits play a significant role in the efficient use of energy. It is essential to keep the consumption of energy, heating, and electricity under control. 20 years ago, only a few dwellings were equipped with heat flow meters, whereas nowadays they are common for the majority of heating network consumers. Thermal expenses for dwellings' heating have decreased noticeably due to the implementation of measurement systems and modern automatically regulated heat supply systems. The next stage consists of supplying apartment radiators with self-regulating thermostatic valves and individual measurement devices. If energy consumption is controlled and self-regulated, the consumer gets into the habit of being involved in the regulation of his or her energy consumption.

As for electric devices, it is also important to avoid unnecessary expenses by selecting more energy-saving devices and using them in a sensible manner, meaning also that it is inefficient to leave electric devices in standby mode. Table 10 "Power consumption of home electrical devices" shows measurement data on the power consumption of domestic electrical devices both in work and standby modes.

Measurements have been made in the average apartment of average consumption habits provided that all devices are indeed turned off when not in use, however not fully, but left in standby mode in order to get quick operation when needed.

As can be seen from the table, domestic electrical devices consume only 55% of energy in operating mode and 45% in standby mode. Supposing that the total power consumption in an apartment amounts to 300–400 kWh per month, it is possible to save 10-15% of the electricity just by changing consumption habits.

Table 10. Power consumption of home electrical devices

		Mode	Capacity (W)	Average (W)	Per 24 hours (kWh)	Per one month	Per one year	Hours of operation

						(kWh)	(kWh)	
1	Desktop computer	operating mode	80–120	100	0,40	12	144	4 hours per twenty-four hours
		standby mode	13	13	0,26	7,8	93,6	
	Desktop computer's monitor	operating mode	36	36	0,14	4,32	51,8	4 hours per twenty-four hours
		standby mode	6	6	0,12	3,6	43,2	
2	Laptop	operating mode	20–36	28	0,22	4,70	56,45	8 hours per twenty-four hours
		standby mode	4–6	5	0,08	2,41	28,94	21 day per one week
3	LCD-television Sharp	operating mode	76	76	0,30	10,64	127,68	4 hours per twenty-four hours
		standby mode	9	9	0,18	5,4	64,8	
4	Digi-box Zuum	operating mode	25	25	0,10	3	36	4 hours per twenty-four hours
		standby mode	18	18	0,36	10,8	129,6	
5	Picture-tube television Sony	operating mode	100	100	0,40	12	144	4 hours per twenty-four hours
		standby mode	0	0	0	0	0	
6	Music centre	operating mode	25	25	0,2	6	72	8 hours per twenty-four hours
		standby mode	6	6	0,10	2,88	34,56	
7	Tape recorder Philips	operating mode	18–24	21	0,04	1,26	15,12	2 hours per twenty-four hours
		standby mode	6	6	0,13	3,96	47,52	
8	Microwave oven	operating mode	1200	1200	0,192	5,76	69,12	10 minutes per twenty-four hours
		standby mode	6	6	0,14	4,29	51,49	
	Total	operating mode			1,8	55,0	659,8	

		standby mode			1,4	41,1	493,7	
		All in total			3,2	96,1	1153,5	

An experiment carried out by Estonian Television some time ago proved that it is quite feasible for households to save electric power through changing consumption habits and taking electricity consumption under control. The broadcaster asked the television audience to turn off all unnecessary, at that point in time, electrical devices and switch off all needless lights, upon which electricity consumption in Estonia fell by 10-15%. Control over one's own electricity consumption allows the saving of energy and the reduction of electric power bills.

3 The activity concept, strategic options, and necessary measures

3.1 Energy production and use

3.1.1. Power-generating fuel consumption

Table 11 “Consumption of power-generating fuels and purchased heat in Tallinn 2020” shows the probable scenario in regard to the consumption of power-generating fuels and purchased heat in Tallinn 2020. Fuel costs and energy consumption in various branches of the economy are shown in greater detail in the following chapters.

Table 11. Consumption of power-generating fuels and purchased heat in Tallinn 2020

Fuel	Unit	Energy production	Industry and construction	Business and service	Household	Total demand	Heating value	Energy (GWh)	Consumption share (%)
Coal	th t		1	1	1	3	7,5	23	0,6
Peat	th t	30				30	2,5	75	1,8
Peat briquette	th t				2	2	4,4	9	0,2
Wood fuel	th tm		2	10	90	102	2,1	214	5,2
Wood chip	th tm	850	6		40	896	1,7	1523	37,2
Waste	th t	200				200	2,9	580	14,2

Natural gas	mln m³	50	26	24	20	120	9,3	1120	27,4
Liquid gas	th t		1		2	3	12,7	38	0,9
Biogas	th t	3		2		5	5,3	27	0,6
Shale oil	th t	1	1	1		3	10,9	33	0,8
Light fuel oil	th t	1	1	1	2	5	11,8	59	1,4
Purchased heat (Iru and CCGT)	GWh		36	68	296	400		400	9,8
Toal power-generating fuel and heat	GWh	2605	336	354	796	4100		4100	100,0
Consumption per capita	MWh per capita							10,4	

Figure 8 “Fuel and heat consumption in Tallinn 2020” characterises prospective fuel consumption and the distribution of purchased heat in Tallinn 2020.

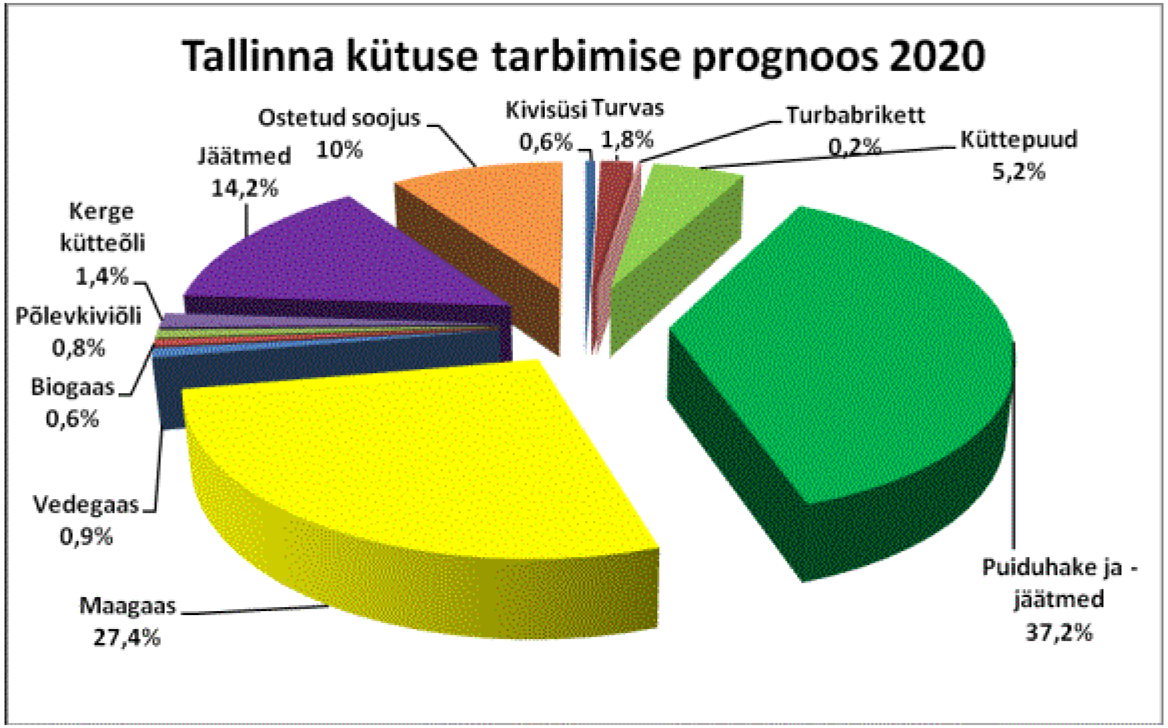

Figure 8. Fuel and heat consumption in Tallinn 2020

[The title of the diagram: 2020 outlook of fuel consumption in Tallinn. From left to right: Natural gas; Liquid gas; Biogas; Shale oil; Light fuel oil; Waste; Purchased heat; Coal; Peat; Peat briquette; Wood fuel; Wood chips and pellet].

If we compare figure 1 "Fuel and purchased heat consumption in Tallinn 2007" with figure 8 "Fuel and heat consumption in Tallinn 2020," we can see that the most significant change in the total fuel consumption is that the usage of wood chips will be 4.5 times as much as in 2007. The main reason is the activity of Tallinn (Väo) Power Plant. Tallinn Power Plant produces electricity for the city and supplies the urban heating network with heat. In Tallinn Power Plant green electricity produced from wood chips covers 8-10% of Tallinn's electric power demand and 20-25% of Tallinn's district heating supply.

Due to the implementation of wood chips and waste in electricity production, natural gas consumption may fall by half, since less heat will be generated in gas boilers. If possible, heat produced by cogeneration system will be used in heating networks.

The consumption of peat, which is a local fuel, will also show some change in the fuel balance. Nowadays, Tallinn Power Plant uses 10% of the total amount of peat.

The consumption of fossil fuels will be decreased and replaced with renewable fuels.

Table 12 "Fuel and energy consumption in Tallinn 2007 and 2020" illustrates the comparison of power-generating fuel, purchased heat and electric power consumed in Tallinn in 2007 with the corresponding forecasts for 2020.

Table 12. Fuel and energy consumption in Tallinn 2007 and 2020.

The table shows that the share of purchased heat and electric power in Tallinn's energy balance is going to fall. It will be replaced with heat and electric power generated in Tallinn Power Plant (Väo), as well as in waste-to-energy plants by waste incineration system. The total decrease of power-generating fuel and purchased energy consumption will amount to 8%. The share of waste as an additional source of fuel will increase by 10%. The share of power-generating fossil fuels and purchased energy in Tallinn's energy supply will decrease by 40% in total, as it will be replaced with wood chips and waste.

Table 12. Fuel and energy consumption in Tallinn 2007 and 2020

		2007			2020			Difference		
Fuel	Unit	Total demand	Energy (GWh)	Share of consumption (%)	Total demand	Energy (GWh)	Share of consumption (%)	th t th cu.m. mln m³	GWh	%
Coal	th t	8	60	1,0	3	23	0,4	–5	–38	–62,5
Peat	th t	0	0	0,0	30	75	1,3	30	75	
Peat briquette	th t	4	18	0,3	2	9	0,2	–2	–9	–50,0
Wood fuel	th cu.m.	142	298	4,8	102	214	3,7	–40	–84	–28,2
Wood chips	th cu.m.	156	268	4,3	896	1523	26,4	740	1255	467,7
Natural gas	mln m³	258	2407	38,4	120	1120	19,4	–138	–1288	–53,5
Liquid gas	th t	3	38	0,6	3	38	0,7	0	0	0,0
Biogas	mln m³	3	16	0,3	5	27	0,5	2	11	66,7
Shale oil	th t	3	33	0,5	3	33	0,6	0	0	0,0
Light fuel oil	th t	13	153	2,4	5	59	1,0	–8	–94	–61,5
Waste	th t	0	0	0,0	200	580	10,1	200	580	
Purchased heat	GWh		986	15,7		400	6,9	0	–586	–59,4
Purchased electric power			1994	31,8		1670	28,9		–324	–16,2

Total energy	GWh		6271	100,0		5770	100,0		–502	–8,0

The use of solar power, not widely spread in our area, is also very essential. Weather conditions in Estonia and the current technical level make it unreasonable to start the active utilisation of sunlight for electricity generation. The latitude and longitude of Estonia allow of 1700 hours of sunlight annually: this is quite diffuse, shines at an acute angle, and breaks through a thick layer of air. Estonian sunlight cannot be compared with such countries as Spain, Italy, Greece, and South-Germany, which are the biggest solar energy consumers and where the amount of sunlight hours reaches 3500 with the sun shining from a very high angle at noon.

Estonian weather conditions and current technical solutions do allow the use of solar energy to heat water, especially in summer. Tallinn has a number of successful examples in this respect. Solar panels and batteries may also be used to generate electric power, accumulate it and the later use it, for instance, as the source of light of a single object or in a traffic light system, etc. The current technical level does not enable the use of solar energy on a large scale, however technical development will definitely expand the range of opportunities for solar energy consumption.

3.1.2. Electric power generation, transmission, and consumption

3.1.2.1. Electric power supply in Tallinn

The major share of electricity is supplied to Tallinn by the main network of Elering OÜ, so that the production and transmission of electric power should be evaluated with a view to Estonia. A part of Tallinn's electricity is produced in Tallinn (Väo) Power Plant, as well as in small-scale power and heating plants, and, in the future, waste-to-energy plants will also be used in this respect. Iru Power Plant, located on the territory of the City of Maardu, has a significant role in supplying Tallinn with energy. Tallinn's consumers use most of the heat produced in Iru Power Plant. Tallinn's atmosphere is also exposed to the emissions of Iru Power Plant pollutants. In the future, the share of Iru Power Plant both in supplying Tallinn with energy and pollution from fossil fuels will fall mainly due to a probable transition to the operation of waste-to-energy plants and the Tallinn Power Plant based on biofuel.

According to the development plan of Estonian power engineering, in Estonia 2020, electic power is going to be produced by 900MW windmills. It will also be necessary to establish wind parks’ balance control stations with the same production capacity, and, moreover, reserve and emergency reserve stations in addition to peak load stations. It is most efficient to use CCGT-technology based on gas turbines in balance control stations, in peak load stations, as well as in emergency reserve stations. It would be reasonable to establish some of these stations in the neighbourhood of Tallinn to supply the city with heat and, through the power transmission lines, electricity.

The electricity production structure is going to be significantly changed, and air pollution from gas emissions will be reduced. According to one possible scenario, in 2020 the city of Tallinn could produce 316 GWh or 16% of the required fully renewable electricity (see green sectors in figure 9 "Electricity supply in Tallinn 2020").

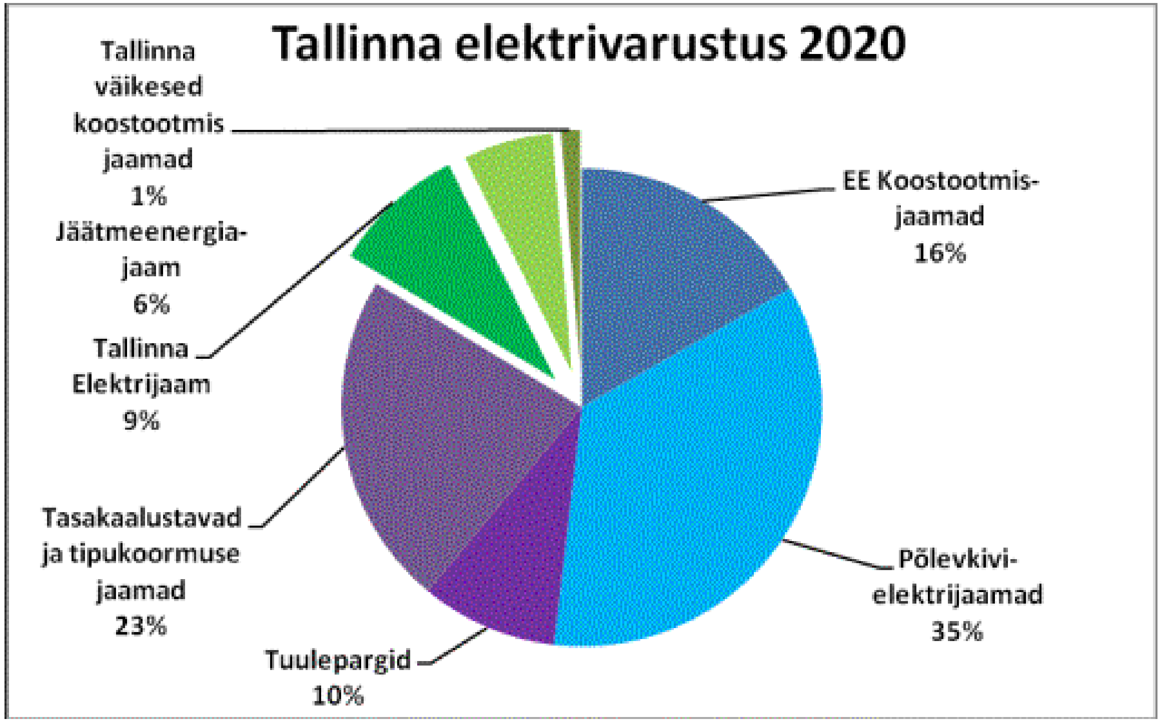

Figure 9. Electricity supply in Tallinn 2020
[From left to right: wind parks; balance control stations and peak load stations, Tallinn Power Plant; waste-to-energy plant; Tallinn's small-scale cogeneration plants; EE Cogeneration plants; oil shale fired power plants]

The structure of electric power output in Tallinn 2020:

Tallinn Power Plant	180 GWh
Waste-to-energy plants	120 GWh
Small-scale power and heating plants	26 GWh
total	316 GWh

In 2020, in addition to its own electric power output, Tallinn will purchase 1670 MWh of electricity from Eesti Energia AS's power transmission line generated in electrical stations outside the territory of Tallinn (see blue sectors in figure 9). According to the development plan of Estonian power engineering,[25] the electricity production structure is going to be significantly changed and air pollution from gas emissions will be reduced. In Estonia 2020, in compliance with the development plans, the total amount of electricity produced from oil shale will comprise only 35-45%, while a significant share will come from power and heating plants and wind parks as a renewable energy sources.
It is most sensible to establish gas turbine plants which would operate as wind park balance control stations and peak load stations, since its contaminants are less harmful than that of shale oil. So Tallinn's indirect CO_2 emissions will be reduced because of purchased electric power.

3.1.2.2. Electric power transmission

Tallinn is supplied with electric power by Elering OÜ 110–330 kV high voltage distribution network. Eesti Energia Jaotusvõrk OÜ (Distribution Network) further transmits electric power to consumers with low or medium voltage of 0,4–35 kV.

According to the estimatess of Elering OÜ, energy losses in main networks amount to 3%. A remarkable share of energy saving concerns modern electricity supply systems balancing methods. Today, the centre of electricity production in Estonia is in Kirde-Eesti region, while one-third of the produced electricity is consumed in Tallinn. Energy losses in general transmission lines can be reduced by an equal division of electric power production in Estonia (power and heating plants, wind parks, balance control stations, reserve stations, peak load stations).
According to data from Elering OÜ, Estonian high voltage substations and transmission networks are mainly in good technical condition. Over the last few years the Veskimetsa, Harku, and Kiisa substations which supply Tallinn with electric power have been reconstructed. Aruküla substation is going to be reconstructed in the next decade, which will include its voltage transformation from 220 kV to 330 kV. A new 330 kV substation can be established in the territory of Muuga harbour. Moreover, transmission lines at a voltage of 330 kV will be conducted through the Aruküla substation, which will reduce electrical supply network losses.

During the next decade Tallinn plans to reconstruct Volta and Paljassaare substations which are currently in a bad technical condition, and to replace high voltage overhead transmission lines between Veskimetsa, Endla, Järve, and Ülemiste substations with underground power transmission lines since overhead power lines impede the city's development. In general, Elering OÜ plans to invest 200 million kroons in, the reconstruction of substations and electrical supply networks annually.

As for Eesti Energia Jaotusvõrk OÜ (Distribution Network), the development of its electrical supply network is mostly connected with consumers' needs. In Tallinn 2007, there were 1,930 medium- and low-voltage substations. Today, there are more than 2,000 substations and annually their number increases by 100-200, depending on the number of new customers. Besides, old substations are being renovated and transformers are being replaced with new ones. The energy losses of modern transformers are 2-3 times less than those of old ones.

It is essential to carry out the transition to standard voltages. Medium-voltage networks are being transformed from 6 kV voltage to 10 kV voltage, and new lines are being installed in a manner that will enable their future transformation to a 20 kV voltage level. Nowadays, no developments are being planned in regard to 35 kV voltage networks, however they still continue their operation.

As for low-voltage lines, in such districts as the City Centre and Põhja-Tallinn, there still remains the situation where electrical supply networks at the voltages of 220V and 380V coexist in the nearest neighbourhood, which results in double energy losses. The whole low-voltage distribution network is going to be transferred into 380V voltage, which, in many respects, depends on electricity consumers' options and opportunities.

Measurement systems that control electric power consumption are being further developed; there are both local and remote measuring devices. Local electric power meters allow a consumer to keep his or her electricity consumption under control at any given time, which contributes to the more efficient use of electric power.

The free market in electric power allows a consumer to choose the most suitable reseller of electricity. A kind of smart network is now being worked out which will allow a consumer to purchase electricity from the nearest producer, so reducing corresponding losses in the power transmission line. Besides, a consumer could limit his or her own consumption in peak hours, for instance by switching off electric heating. These actions will reduce peak loads and losses in the power transmission lines and will allow an electric generator to remain in an optimal operation mode.

Today, according to the estimates of Eesti Energia Jaotusvõrk OÜ (Distribution Network), electric power transmission losses in the urban electrical supply network amount to 7%. Eesti Energia Jaotusvõrk OÜ is looking for technical solutions to reduce these losses. All these measures will contribute to the decrease in network losses and in the total electricity demand. Besides, a consumer will get the opportunity to reduce his or her own consumption rate.

3.1.2.3. Electric power consumption

According to data from the collected volume "Tallinn in numbers," electricity consumption in Tallinn 2007 amounted to 1996 GWh, and the maximum load was 448 MW. Electricity consumption by enterprises and households has been divided as follows:

- enterprises 1537 GWh 77%
- household 459 GWh 23%
- total 1996 GWh

The same level of consumption is forecasted in 2020. A certain level of electricity saving is being achieved by the present consumers, which is balanced by additional new consumers.

Elering OÜ has investigated the outlook for electricity consumption in Tallinn for the next decade (see figure 10 "The maximum consumption of electricity in Tallinn according to Elering OÜ forecasts"), and, in compliance with their estimates, electricity consumption is going to rise. In case of a slow rise, the peak load of electricity consumption in Tallinn 2020 will amount to 498 MW, and if a faster rise it will be 625 MW. Tallinn must organise its electricity consumption in such a manner that would secure a minimum increase in consumption levels and that the rise in the peak load would not exceed 1% per year, corresponding to the slow upward tendency planned by Elering OÜ. In order to decrease the general demand for energy in Tallinn, it is also essential to avoid an increase in the peak load in electric power consumption.

If the maximum load rises, it is not recommended to let the actual electricity consumption in Tallinn grow. For this reason, all energy-saving measures must be implemented. A positive aspect is that a part of the electricity consumed in Tallinn is covered by the renewable fuel used in Tallinn (Väo) Power Plant, in waste-to-energy plants, and in the windmill electric generating plant located on the territory of Tallinn (Paldiski, Vääna). Losses in the electrical supply network significantly reduce due to the fact that the electricity is supplied to consumers from plants directly located in Tallinn.

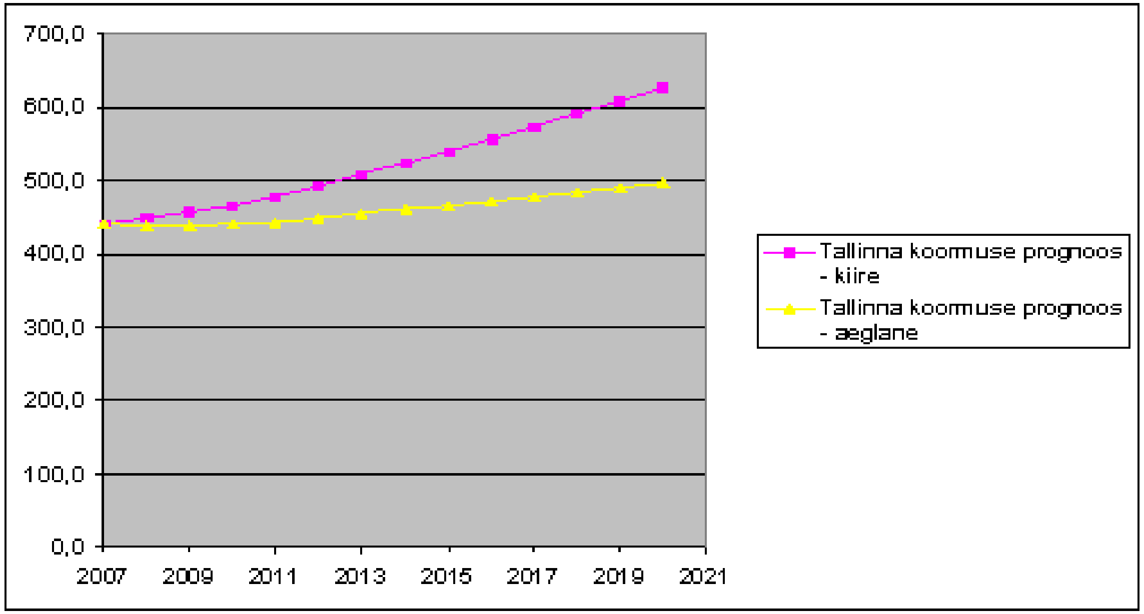

Figure 10. The maximum consumption of electricity in Tallinn according to Elering OÜ forecasts
[Yellow line: Tallinn's load forecast-slow, Purple line: Tallinn's load forecast-fast]

Essential electricity-saving measures are the following:

- reconstruction of main networks and high-voltage substations by Elering OÜ
- reconstruction of distribution networks and medium-voltage substations by EE Jaotusvõrk OÜ
- application of energy-saving technologies in the course of production activities by the private sector
- application of more energy-efficient sources of light in street lighting by public utilities
- application of energy-saving lamps in private households
- changing of consumption behaviours by residents

Total costs related to the implementation of the above said electricity-saving measures amount to 300-400million kroons a year, which will be partly incurred by Elering OÜ, Eesti Energia Jaotusvõrk OÜ, and the private sector. The duties of the City Government include promulgation of these activities, the distribution of information, and application of the said measures in the economic sector that is in the sphere of its responsibility.

With the application of energy-saving measures it is possible to save 10-20% of electricity by 2020, which will be balanced by additional new consumers. Considering the joint impact of both the existing consumers and the potential new ones, it is believed that the total demand for electricity in Tallinn 2020 will stay at the same level as in 2007, i.e. 1996 MWh.

3.2. Heat economy

Tallinn's main heat supplier is AS Tallinna Küte, which owns more than 60% of the total heat supplied to the city. Therefore the development of urban heat supply systems is closely connected with the operations of AS Tallinna Küte. The other biggest heat suppliers are Fortum Termest AS, AS Eraküte, small-scale boiler houses, and individual heating.

In 2007, AS Tallinna Küte purchased 54% of its heat from the Iru Power Plant (which was passed on to consumers in Lasnamäe and the City Centre districts), and produced 46% in its own boiler houses using natural gas (which was supplied to western-Tallinn districts).

Demand for heat in Tallinn has decreased over the years. The thermal load significantly reduced in the 1990s as well as at the beginning of this century, following which matters have remained stable, however, a certain level of decrease in heat consumption has been observed in the last few years. In the next decade, heat consumption is also forecast to reduce by 2% annually (see figure 11 "AS Tallinna Küte heat output and outlook").

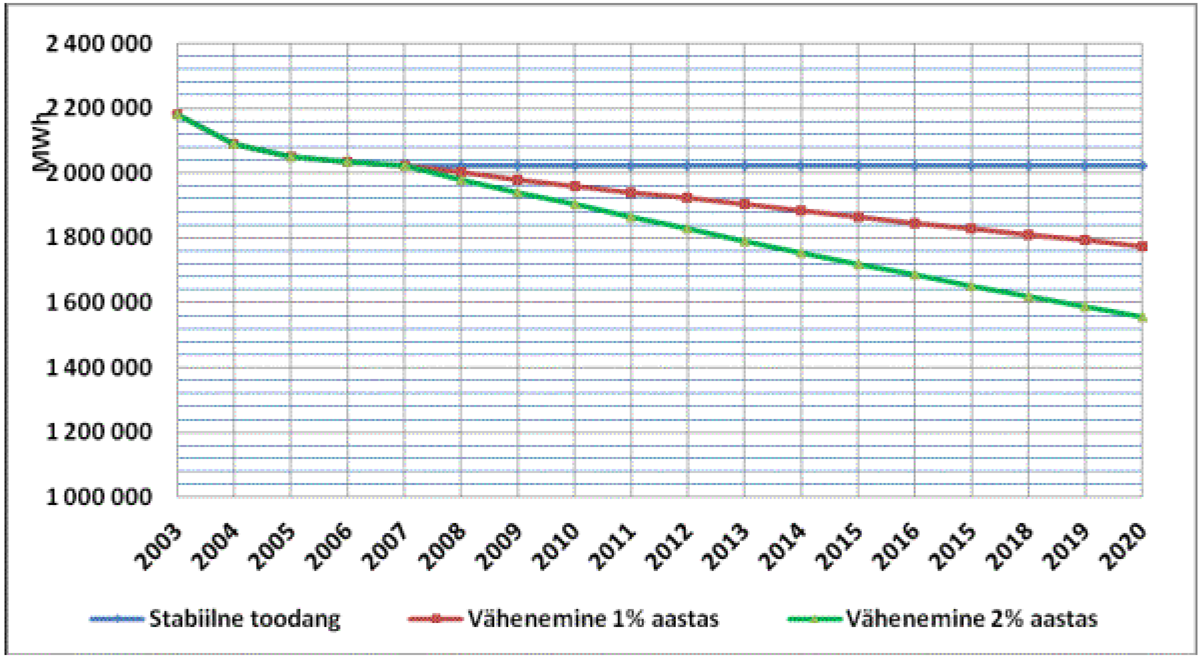

Figure 11. AS Tallinna Küte heat output and outlook
[Blue line: Stable output; Red line: 1% reduction per year; Green line: 2% reduction per year]

AS Tallinna Küte heat output in 2007 and 2020 outlook

- in 2007 2021 GWh
- 2020 outlook 1556 GWh

With an annual 2% decrease in heat consumption and the application of energy-saving measures, the overall heat output of AS Tallinna Küte will decrease by 445 GWh or 23,1%.

The decrease in heat consumption can be achieved with the application of the following energy-saving measures:

- renovation and insulation of existing dwellings;
- construction of new dwellings equipped with advanced insulation;

- renovation of heating networks and reduction of losses;
- renovation and balancing of dwellings' heat supply systems.

Cogeneration-based district heating is environmentally friendly and the most preferable method of heating supply in Europe. In order to preserve continuous and effective operation and the development of cogeneration-based district heating, the city's planning must secure connection with the district heating of as many areas and dwellings with dense populations as possible.

Apart from the reduction of heat consumption, there is another quite important factor in heat production changes. The major part of heat supplied through the heating networks had been produced in AS Tallinna Küte using natural gas. In 2007, AS Tallinna Küte boiler houses produced 46% of its heat from natural gas and purchased 56% from the Iru Power Plant, which also used natural gas as its main fuel. During the cogeneration process, Iru Power Plant uses classical steam generation and steam turbines of low output efficiency.

On the production of heat, it is vital to apply modern production processes and use fuels that cause less pollution to the environment.

According to the regulations[26] stipulated by Euro Directive, it is necessary to develop heat production in the following directions:

- use of renewable fuel for heat production;
- use of waste in heat production instead of dumping it in landfill;
- implementation of an effective cogeneration system;
- if possible, the use of plants based on gas turbines (CCGT) with high output efficiency.

In order to follow the above-mentioned regulations, Tallinn's energy economy has to implement the following changes in heat production by 2020:

- connect Eastern and Western Tallinn's district heating networks;
- exploit production potential of Tallinn (Väo) Power Plant;
- consider the opportunity of using Tallinn's waste as a fuel;
- if possible, start using wastewater residual heat in AS Tallinna Vesi Sewage treatment plant for district heating;
- implement the maximum use of biogas;
- in order to compensate for the variable output of windmill electricity generating plant, establish gas turbine plant in the territory of Tallinn and connect it with Tallinn's district heating network;

According to § 14[1] of the Estonian District Heating Act, if new production capacity is needed and several entrepreneurs have expressed their wish in written form to conclude an agreement, a tender shall be arranged for all those network operators.

3.2.1. Tallinn (Väo) Power Plant

Tallinn Power Plant[27] (initial name is Väo power plant), which is located on the outskirts of Tallinn in the old Väo quarries, was put into operation at the end of 2008. The owner of the plant is AS Tallinna Küte, which belongs to the French concern Dalkia International SA.

Tallinn Power Plant has been developed to use local fuel in its operation: wood chips and peat. Using wood chips as a renewable fuel is very effective from the point of view of the environment - its CO_2 emissions into the atmosphere are not considered harmful.

The designed performance capabilities of Tallinn Power Plant are the following:

- nominal electrical power 25 MW_e
- nominal thermal power 49 MW_s
- gaseous combustion product generated by condenser up to 18 MW_s
- gross thermal power up to 67 MW_s (along with a condenser generating gaseous combustion product)
- electric power output per year 160–180 GWh
- heat output per year 400–500 GWh
- plant building cost 1.1 billion kroons
- plant founder OÜ Digismart

The present owner of Tallinn Power Plant is AS Tallinna Küte, which manages Tallinn's district heating network. The total amount of heat generated in the Power Plant is transmitted to the heating network of AS Tallinna Küte Lasnamäe district, fully covering the demands of Eastern Tallinn (Lasnamäe and the City Centre) for hot water in summer and providing it with the base load for heating in winter.

Heat output at the nominal load varies from 400 to 500 GWh per year. Production volume depends on both the consumption level and the operation of the condenser generating gaseous combustion product. The maximum heat output rate at 500 GWh can be achieved provided that the condenser generating gaseous combustion product operates with a full load, the whole heat is further fully used, and the Plant works all year round. Before Tallinn Power Plant was put into operation, Lasnamäe heating network had been obtaining most of its heat from the Iru Power Plant. Tallinn Power Plant uses wood chips as its main fuel, which is much cheaper than the use of natural gas. So it is obvious that in the future AS Tallinna Küte is going to purchase from Tallinn Power Plant as much heat as possible, correspondingly reducing the amount of heat purchased from Iru Power Plant.

Tallinn Power Plant's operation is based on renewable fuel, which is rational from the point of view of both consumers and the environment. Heat purchased from Tallinn Power Plant will stabilize heating prices and release the country from dependance on prices for natural gas purchased from the Russian Federation. Besides, burning fossil fuel does not cause CO_2 emissions into the atmosphere **(?!)**.

3.2.2. Waste incineration

In Europe, half the household waste on average is being incinerated to generate energy. This method is mostly common for France and Sweden, where waste has been turned into a subject of sale. In Estonia, the mass incineration of waste has not been implemented so far.

Nowadays, the Iru Power Plant is making arrangements for probable mass incineration of waste at the cogeneration plant. It is planned to establish waste-to-energy plant on Tallinn's Western boundary near the Iru Power Plant, presumably incinerating waste from Tallinn and its neighbourhood.

Performance capability of the planned waste-to-energy plant:

- amount of incinerated waste 120 000 – 220 000 tons per year
- nominal electrical power 10–18 MW_e
- thermal capacity 25–50 MW_s
- electric power output per year 70–140 GWh_e
- heat output per year 200–310GWh_s
- plant building cost 1–1,5 billion kroons
- plant founder issue is being negotiated

The performance capability of the waste-to-energy plant and its output depends on several factors, such as the intended waste volume to be incinerated, or the principles of its co-operation with other plants and heating networks.

In fact, it is still unclear where Tallinn is going to direct household waste, who is going to be the owner of the waste-to-energy plant, and what are the long-term contracts for heat transmission systems.

3.2.3 Increase in the share of a renewable fuel

It is reasonable to build production units based on biofuel which would supplement Tallinn Power Plant operating on wood fuel and peat, since, today, there is everything needed in terms of wood industry and peat resources for the construction of supplementary plant(s) in Tallinn for the sake of creating environmentally friendly conditions, price stabilisation, and the reduction of dependance on gas resources. It would be reasonable to establish a plant based on wood fuel (peat) with a production capacity of 65-75MW which would supplement the existing Tallinn Power Plant with 67MW of thermal power, and contribute to the increase in the use of local fuel in Tallinn by up to 50%.

- nominal thermal power 65-75 MW_s
- gaseous combustion product generated by a condenser up to 15 MW_s
- heat output per year 400–435 GWh
- plant building cost 0,4 billion kroons

3.2.4. Use of wastewater residual heat

In Tallinn, after wastewater has been purified in the Paljassaare Sewage treatment plant, it is discharged into the sea. The temperature of this wastewater amounts to 8–20 °C, depending on the season and air temperature. So a significant amount of heat which might have been used in urban district heating systems with the use of heat pumps is being dumped into the sea. Besides, energy which has been generated by the use of heat pumps is considered a renewable. Our neighbouring countries, Finland and Sweden, have been generating heat from wastewater with the use of heat pumps for quite a long time already.

In Tallinn, a number of researches have been carried out on the use of wastewater residual heat, the results of which are also available in the newspapers[28]. The city of Tallinn and AS Tallinna Küte are seriously interested in and support this technical solution. According to these researches, it is possible to generate 20MW of heat from wastewater with the use of heat pumps, while electricity costs will comprise only 30%.

Performance capability of the heating plant based on wastewater residual heat:

- plant thermal power 20MW
- consumed electrical power 7-8MW

- heat output per year 100–125 GWh
- electric power demand per year 30–40 GWh
- plant building cost 120–150 million kroons
- joint pipe cost 30–40 million kroons

It would be rational to transmit heat generated in sewage treatment plant to Western-Tallinn's district heating network. From the technical point of view, it is not that complicated to carry out the transmission of heat generated in sewage treatmant plant to the district heating network. Pipelines of the district heating network in Western Tallinn cover Põhja-Tallinn's Pelguranna and Karjamaa residential districts. Trunk pipelines of the district heating network, which are 400 mm in diameter, extend on both Sõle-Sitsi and Kopli-Paavli from their street crossing. Those pipelines that are BT 300-400 mm in diameter and 2.5 km long would be enough to transmit heat generated in the Paljassaare Sewage treatmant plant to the district heating network's trunk pipeline at this Sõle-Sitsi and Kopli-Paavli street crossing.

The electricity needed to operate of heat pumps can be fully or partly produced by gas engines based on biogas released in sludge-digestion chambers, as well as on natural gas. It is also possible to reheat delivery water in boiler houses based on biofuel in order to provide heating networks with water of the required temperature in winter periods.

The permanent co-operation of AS Tallinna Soojus, AS Tallinna Küte, and AS Tallinna Vesi is a primary condition for the establishment of a heat pump that would use wastewater residual heat. According to research results heat produced in the sewage treatmant plant from wastewater residual heat is much cheaper than that generated in gas boiler houses. If the planned housing construction on the territory of Paljassaare took place it would be possible to provide those dwellings with heating and cooling systems. The establishment of new truck pipelines will enable the connection of the heating networks of several Sõle-Kopli residential districts and to close the local small-scale boiler houses that release too many contaminants into the atmosphere.

3.2.5. The maximum use of biogas

Biogas is released upon the digestion of organic waste. Depending on the surrounding environment, biogas contains 50–70% of methane and its calorific value is 5–7 MWh / 1000 m^3. In Tallinn, biogas is generated and used in the following places:

- Pääsküla landfill;
- Paljassaare Sewage treatment plant.

The Pääsküla landfill has been using biogas since 1993. In the beginning, biogas was used only as a boiler fuel, but since 2001 it has also been used in the gas engine for electricity generation. After the closure of the landfill in the previous year, the maximum biogas output was up to 1000 m^3/h, and the annual output exceeded 5 million m^3. This volume was enough to provide heat for 1000 apartments in Pääsküla. Today the total amount of gas has decreased by up to 300 m^3/h. All the biogas is used to generate heat and electricity. Heat is transferred to the AS Tallinna Küte heating network, and the corresponding electricity is transmitted to Eesti Energia AS power network.

The sludge-digestion chambers in Paljassaare Sewage treatment plant release 2,5 million m^3 of biogas annually, which is used in the gas engine as a boiler fuel, and the remaining product is burnt in a so-called "candle." So biogas losses comprise 10–25% of the total amount.

There are several ways to maximise the use of biogas:

- installation of a second gas engine to generate electricity and heat;
- use biogas as a boiler fuel to produce heat and transfer it to the district heating network.
  It would be rational to include the operation of heat pumps using the residual heat of wastewater.

These measures make it possible to get 2–3 GWh of energy per year. The investment needed for the installation of a supplementary gas engine would be 8-12 million kroons. The use of biogas along with wastewater residual heat is included in the sewage pumping station price.

In addition, Tallinn's (Jõelähtme) landfill also plans to start exploitation of biogas in 2011. Preparations are being made to secure the transmission of the electricity produced through the power network, as well as the direct use of heat in room heating. In theory, biogas can also be transferred to Maardu, where a cogeneration unit based on biogas could be established; after that it would be possible to transfer heat through the Maardu-Iru-Tallinn heating network, so reducing the use of fossil fuels in the energy generation process.

The investment in the construction of power and heating plant with a gas engine using biogas in Tallinn's landfill is 10-20 million kroons. An additional 6-10 million kroons will go to the construction of a gas pipe to transfer gas to the city of Maardu, however, this process helps in the full utilisation of heat produced by the cogeneration system.

The performance capabilities of power and heating plant using a gas engine based on biogas are as follows:

• thermal power	1–2 MW
• electrical power	1–2 MW
• heat output per year	8–15 GWh
• electric power output per year	8–15 GWh
• plant building cost	10–20 million kroons
• joint pipe cost	6–10 million kroons
• plant founder	Tallinna Prügila AS

3.2.6. Heat supply from the combined cycle gas turbine power plant

According to the Development plan of the Estonian Electricity sector, it is rational to supplement wind farms with quick starting power plant that would balance the wind turbine generation system. From the technical point of view, gas turbine plants would be suitable for this purpose. Subject to the technical requirements of Elering OÜ, those companies that have established wind farms must organise the construction of a balancing station to connect the wind farms with power networks. This regulation is also prescribed by the Development plan of the Estonian Electricity sector until 2018.

The said target can be successfully achieved by the construction of a combined cycle gas turbine power plant (*CCGT PP – Combined Cycle Gas Turbine Power Plant*). This type of power plant offers quick starting and prompt control in case of changes in airflow direction. If possible, it would also be rational to use heat produced by the plant.

One of the possibilities includes the construction of a balancing gas turbine power plant in the Tallinn area; research is to be carried out to explore the chances of transferring heat produced in the plant to the heating network.

The performance capabilities of a potential combined cycle gas turbine power plant intended to balance wind farms are as follows:

- type of plant combined cycle gas turbine power plant
- electrical power 100–200MW
- thermal power 70–140MW
- electric power output 500–1000GWh
- heat output 300–600GWh
- plant building cost 1–2 billion kroons

The capacity and electric power outputs of power and heating plant aimed to balance wind farms depends on the capacity and operating mode of the balancing wind generators. Produced thermal capacity depends on both these factors and on the operating mode of the heating network.

The present Action Plan defines both a probable scenario for the power and heating plant intended to balance wind farms as stipulated by the Development plan of the Estonian Electricity sector, and its installation in the outskirts of Tallinn by the company responsible for wind farms. The whole project is still in the pre-appraisal stage as this possibility has not yet been fully investigated. AS Tallinna Küte has the opportunity to purchase heat from the power and heating plant and transfer it to customers through its heating networks.

3.2.7. Connection of heating networks between Eastern and Western districts in Tallinn

Tallinn has two large district heating networks:

- Eastern Tallinn's heating network – Lasnamäe and Kesklinn (the City Centre); most of this heat is supplied by the Iru Power Plant; nowadays Tallinn Power Plant is also on the list of heat suppliers.
- Western Tallinn's heating network – Mustamäe, Õismäe, Kristiine, and Põhja-Tallinn; heat is supplied by the Mustamäe and Kadaka boiler-house.

These two heating networks are not interconnected, and there has been no way to transfer heat from the western part of Tallinn to the eastern one and vice versa. At the same time, two power and heating plants, i.e., the Iru and Tallinn Power Plant are located in the East of Tallinn and supply heat to Lasnamäe and the City Centre district heating networks only. The Western part of Tallinn obtains heat from boiler-houses using natural gas.

AS Tallinna Küte has already been planning for a number of years to connect the heating networks between the eastern and the western districts in Tallinn. The construction of the joint pipe began in 2010, and it is planned to put it into operation in 2011 during the heating season.

Performance capability of the joint pipe is as follows:

- length 3.2 km
- diameter 800 mm
- cost ca 240 million kroons
- owner Tallinna Küte

The connection of the heating networks will contribute to more effective planning of the urban heat supply system by applying the most rational heat production solutions and installing an open-cycle heat pipe in the city. It would allow the production of the major part of heat in power and heating plants, most likely in the plants based on renewable fuel, and to cover peak loads with the recently renovated AS Tallinna Küte Kadaka and Mustamäe gas boiler-house(s) with a high power efficiency that complies with all environmental norms. These measures will also secure the full utilization of heat produced by cogeneration technology based on renewable energy sources.

3.2.8. Other heat producers

The heat output of the other largest heat producers in Tallinn, Fortum Termest AS and Eraküte AS, serving the same number of consumers, is going to fall by 23%. This reduction will be achieved by both the modernisation of boiler-houses, the construction of new boiler-houses and the application of energy-saving measures by consumers. The gas consumption of the boiler-houses of these companies will stay at the same level.

The share of the heat produced by the local boiler-houses of enterprises and residential areas (which comprises 5-8% of the heat produced in total) will not change: the reason is the economical use of heat by both local boiler-houses, heating networks' owners and by consumers.

It is essential to add some more local power and heating plants, such as power and heating plants with gas engines to the existing boiler-house and the heating networks. Both Eesti Energia AS and Fortum Termest AS are carrying out research and preparations in this respect.

3.2.9. Heat pumps

The use of heat pumps in those areas with no district heating network is an essential trend in the heat supply issue. Single-family and small dwellings, as well as detached buildings (warehouses, offices, etc) can be successfully supplied with heat through heat pumps. Heat pumps use solar energy, which has been accumulated in the ground or air, and electric power is used only in the course of energy transmission into a building. The average COP quality factor of a heat pump is 2-3, which means it uses 2-3 times less electric power than the equivalent amount of heat produced.

In Sweden, for instance, there are about half a million of these heat pumps in use, which is why this country is rightly considered a leader in this field. Sweden exploits both air-to-air, air-to-water, and ground source heat pumps.

In Estonia, air-to-air and air-to-water heat pumps are commonly used. Ground source heat pumps are used to a lesser extent. Ground source heat pumps are used with a horizontal ground pipeline. The use of a vertical borehole, which is more suitable for heat pumps, is an expensive choice, and it is not that easy to start their implementation in Estonia.

In Estonia, the implementation of heat pumps began a decade ago, and since then has made a decisive breakthrough. In Estonia 2007, there were 10,000 heat pumps with a total capacity of 60MW, which produced 160GWh of heat, and the electric power consumption amounted to 53GWh. The number of installed heat pumps is going to increase by up to 20,000 by 2020 for a total capacity of 120MW and 300GWh of heat output, which comprises a significant amount of the heat consumed by Estonian residents. Considering that half of these pumps are going to be installed in Tallinn, it will contribute to a considerable reduction in the amount of fuel consumed in Tallinn's households.

3.2.10. Potential heat supply in Tallinn

From the point of view of the environment the flexibility and effectiveness of heat supply in Tallinn would improve a great deal if all the abovementioned proposals were put into practice. The first step in this direction has already been made. Beginning in 2008, Tallinn (Väo) Power Plant, based on renewable fuel, was put into operation. Eesti Energia AS is working on the preparation of the project for the construction of the waste-to-energy plant. A grounding has also been given to the construction of the joint heating pipe between the western and the eastern districts of Tallinn.

In order to modernise heat supply in the western part of Tallinn, it makes sense to install a new gas engine in the Paljassaare Sewage treatment plant and establish a plant with a heat pump which would use wastewater residual heat. The succeeding steps depend on the construction of the power plant intended to balance wind farms as well as on a potential opportunity to obtain its heat for the district heating network.

For the further development of the heat economy it makes sense to pay special attention to the implementation of the above-mentioned energy production opportunities by 2020, which will contribute to the maximum use of renewable fuels and energy produced through the cogeneration process.

Table 13 "Heat supply in Tallinn 2007 and 2020" illustrates heat supply in Tallinn 2007 and the corresponding outlook for 2020.

Table 13. Heat supply in Tallinn 2007 and 2020

Heat producers	2007	%	2020	%
Iru Power Plant	1,210	36.1		
Väo Power Plant			500	18,7
Waste-to-energy plant or plant based on renewable fuel			10	11.6
Wastewater resource heat pump system			125	4.7
CCGT based on gas and/or peak load boiler-houses	825	24.6	615	22.9
Fortum Termest AS	170	5.1	160	6.0
Eraküte (Tallinna Küte)	75	2.2	60	2.2
Other boiler-houses	220	6.6	230	8.6
Heat pumps	80	2.4	200	7.5
Individual heating	770	23,0	480	17.9
Heat consumers				
Enterprises	1,028	30.7	823	30.7
Private consumers	2,322	69.3	1,857	69.3
Total	**3,350**		**2,680**	**100.0**

Figure 12 "Heat supply in Tallinn 2020" shows the probable heat supply in Tallinn 2020 provided that the above-mentioned proposals have been fully implemented. As can be seen from the table these data differ significantly from those of figure 3 "Heat production and purchase in Tallinn 2007." By 2020 heat supply is going to change in different ways, including the implementation of renewable fuel and various technologies.

Provided the foreseeable development takes place half of the necessary heat will be produced from a renewable fuel, i.e., from wood chips, waste, and with the use of a heat pump. Renewable energy is being used in large-scale power and heating plants, some boiler-houses, and in the private sector. 23% of the heat demanded is going to be produced by peak load power plants. Provided the connection of Tallinn's heating networks has been made, this task may be undertaken by the renovated boiler-houses in both Mustamäe and Kadaka which belong to AS Tallinna Küte, and by the Iru Power Plant in prospect (its boilers are not equipped with Low-Nox burners). An essential change is going to take place in the private sector: its share will still comprise 25%, of which 7% of heat supply will belong to heat pumps and 18% to individual heating. Individual heating is based on both renewable fuels and natural gas.

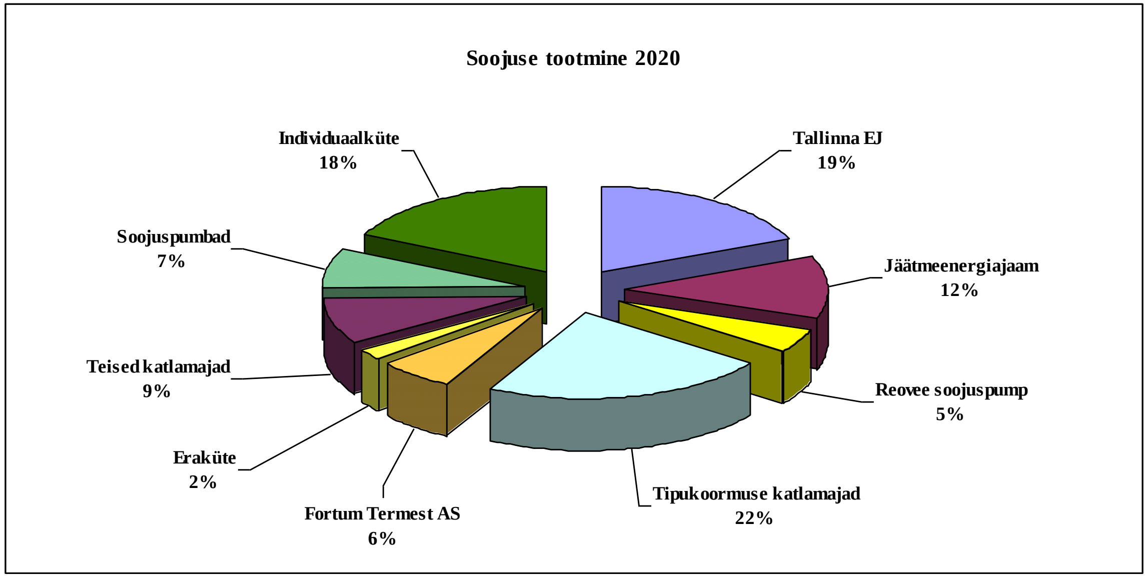

Figure 12. Heat supply in Tallinn 2020

[Title of the diagram: Heat production in 2020. From left to right: Fortum Termest AS, Eraküte, Other boiler-houses, Heat pumps, Individual heating, Tallinn Power Plant, Waste-to-energy plant, Wastewater resource heat pump system, Peak load boiler-houses].

As for heat consumption in 2020, the private consumers-to-enterprises ratio will remain the same as it was in 2007, i.e., 70% of heat will be consumed by private consumers while the share of enterprises will amount to 30%. The total consumption of heat is going to fall by 20% due to the implementation of energy-saving measures in heat production and transmission as well as by dwellings.

3.3. Transport and traffic

The rapid development of the city and its suburbs has resulted in a remarkable deterioration of the efficiency of urban traffic in both Europe and Estonia, since a large number of people who use their vehicles intensively are concentrated in a small area. At the same time, little room has been left for the development of public transport infrastructure. Therefore transport planners have to accomplish a complicated task, i.e., how to minimise traffic jams, and how to make traffic in the city and its suburbs more efficient, safe, fuel-saving and environmentally friendly, so that it improves the living and working conditions of residents and enhances economic growth. [29]

In Tallinn 2007 there were 397,000 residents. Due to the city's bow-tie form - it is located between the Ülemiste lake and the Gulf of Finland (the isthmus is 2.4 km long), and with a long shoreline - it is necessary to deal with transport issues that are comparable to the problems arising in cities with much larger populations. For the creation of people-friendly traffic conditions it is essential to handle the transport system issue in terms of both its planning and the use of land in Tallinn and its suburbs as a whole.

Recommendations from the European Commission for the transport system development:

- to increase the value of active modes of transportation (public transport, walking, journeys by bicycle);
- to reduce the negative impact of urban transport on the environment by the use of an efficient transport system;
- to reduce growth in the traffic flow and the demand for vehicles;
- to provide all residents with access to the main transport services;
- to improve the interconnection of private sectors related to the operation of urban transport;
- to ensure the awareness of the target group connected with the field of urban transport in Europe in regard to the benefits of implementing energy-saving measures in the transport sector.

3.3.1. Scenarios in the development of the transport system until 2035

Three probable scenarios in the development of the transport system in Tallinn and its neighbourhood have been worked out up until 2035[30], the financial support of which depends on local governments and the state, as well as on enterprises and investment priorities.

1. “A random city” – proceeding with the continuation of present trends, i.e., chaotic use of land and non-integrated planning at each level, rapid increase in the number of vehicles, chaotic urban development, and transport policy concentrating on the development of Tallinn's central roads and highways.

2. “Suburb” – polycentric suburbs tending to the active use of urban transport along with multifunctional boroughs and parts of the city, integrated planning at each level.

3. “A dense city” – small-scale commuting, growth of Tallinn's population density, transport policy concentrating on non-vehicular traffic and urban transport.

Figure 13 “Changes in the frequency of vehicle use in Tallinn according to "A random city" scenario (as on a working day)” illustrates changes in the use of various transportation modes in chaotic urban development conditions, as this is the most probable scenario, which is however at the same time the most uncomfortable one.

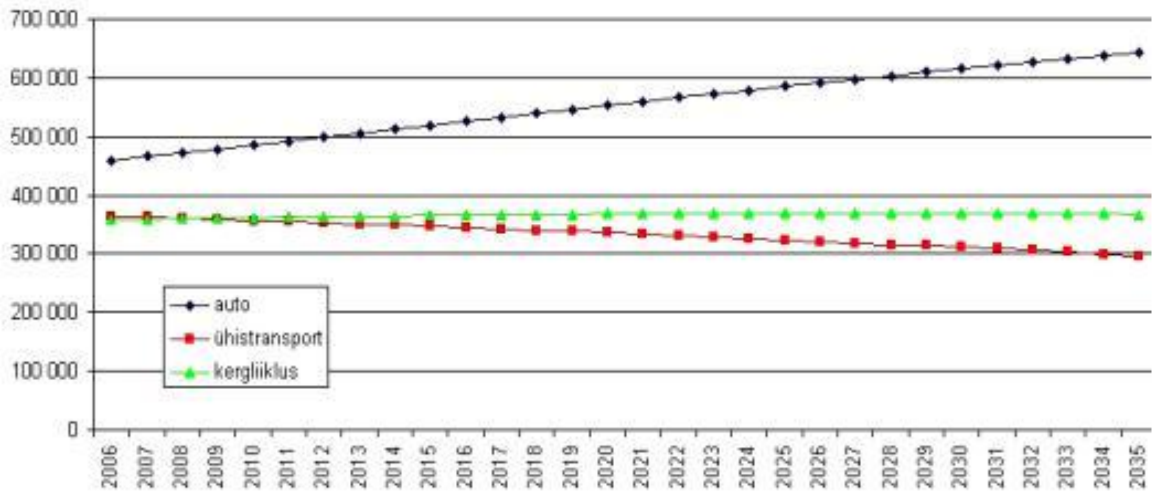

Figure 13 “Changes in the frequency of vehicle use in Tallinn according to "A random city" scenario (as on a working day)“
[Black line: cars; Red line: public transport; Green line: non-motorized traffic].

If the development of both the city and the transport sector are not regulated, the city traffic develops in a random mode, resulting in a remarkable increase in vehicle use and a decrease in the use of public transport, while non-motorised traffic remains at the same level. This kind of development is not considered satisfactory.

It is essential to regulate the development of the organisation of urban traffic with the application of "a dense city" or "suburb" scenario, which would contribute to an increase in both non-motorised traffic and the use of public transport, and limit the growth of the use of private vehicles. It would make sense from the point of view of energy consumption and environmental conditions, as well as people's health, to encourage people to change their consumption habits and increase the level of public transport and non-motorised traffic, i.e., journeys by bicycle and pedestrians.

3.3.2. Public transport

Tallinn has turned into a city in which private vehicles are frequently used. The development of infrastructure that would make public transport more preferable over private vehicles is still at an early stage, which is why, at the present moment, public transport cannot satisfy all expectations, in other words, an attractive alternative to a private car. In the case of traffic jams, the speed of travel of public transport does not significantly differ from that of other vehicles, so it is considered to be too slow.
The development of public transport will allow the city to save long-term costs on the investment in traffic capacity (new wider roads, multilevel crossroads, etc.), as well as on fuel consumption rates, and compensate for the consequences of traffic pollution.

State, nature, and the extent of public transport are related to the development of the urban environment, so corresponding development of Tallinn's neighbourhood must also be kept in mind. Potential transportation requirements, including the needs of disabled people,[31] must also be taken into consideration when planning of the use of land in the city's area.

It is logical to make a full-scale development of public transport in the city which would enable the saving of fuel and maintain the smooth operation of the whole transport sector. For this purpose, Tallinn transport sector strategy has worked out corresponding measures and proposals.

Support of the public transport priority status

- It is necessary to ensure the priority of public transport in Tallinn's traffic (traffic lanes, traffic lights that partly regulate public transport traffic, bicycle paths and footpaths, if necessary, construction of pathways for both bicycles and public transport, etc.).
- Pay special attention to the development of environmentally friendly electrical transport.
- Traffic in the city centre shall be regulated in favour of public transport.

Enhancement of public transport efficiency

- To implement integrated measures for the enhancement of the efficiency of public transport.
- To improve service levels and public transport quality, including availability, environmental concerns, the availability of information for passengers, sufficient travel speed, high customer service levels, tidiness, comfort, safety, reliability, and regularity.
- Public transport is to be developed to meet the requirements of people with special needs (including disabled people and passengers with baby buggies); and ensure reasonable prices and availability for all customers.

The objective of Tallinn's development plan for 2009–2027

- Development of an integrated, comfortable, safe, resource- and energy-saving traffic environment which would provide Tallinn's residents with good transportation to their homes, work, service and shopping centres, and to leisure areas.

Opportunities for achieving the objectives of Tallinn's development plan for 2009–2027:

- Organisation of public transportation
- Organisation of researches and projects related to public transportation
- Expansion of the transport network within the city limits
- Development of school bus service
- Renewal of public transport fleets taking into account the needs of disabled people, elderly people, and passengers travelling with children
- Development of the ticket-sale system, implementation of electronic ticket-sale system
- Optimising of both public transport lines and schedules
- Development of the public transport infrastructure
- Construction of new highways and multilevel crossroads
- Construction of non-motorised and bicycle pathway networks
- Construction and renovation of street lighting system
- Development of the "Park and go" system

In the development of urban transportation priorities must be set for the organisation of the transportation system. The order of priorities in the development of the transport organisation will be as follows:

1) construction of non-motorised pathways and their active promotion;
2) development of public transport and the corresponding traffic organisation;
3) development of both vehicular and related street network.

3.3.3. Use of biofuel in the transport sector

In 2007 the use of biofuel in the transport sector was insignificant, i.e. 0.15% of the total consumption of transport fuel. According to the European Union Directive[32] and the above-mentioned development plan, in Estonia 2020 the share of biofuel in the total amount of fuel consumed in the transport sector should comprise 10%. First of all, biofuel should be used by that urban transport which has the highest traffic load. The Tallinn City Government has a significant role in the regulation and implementation of this trend.

Major problems in regard to biofuel production and consumption are the following:

- there is no information about the efficiency and impact of biofuel consumption;
- vehicle manufacturers are suspicious about the use of biofuel;
- biofuel, or other fuels that contain biofuel, have poor competitiveness;
- availability of biofuel requires additional investment to be made by merchandisers;
- statistical data on biofuel needs to be modernised;
- there are no European standards for biofuel;
- biofuel producers find it difficult to obtain financial support;
- there are no development programmes for second generation biofuel.

From the point of view of fuel economy, we need to open up biofuel for development: develop the petrol station network and encourage consumer awareness on this point

3.3.4. Number of vehicles and fuel demand

In Tallinn at the end of 2007 the number of vehicles was 251,000, of which 194,000 or 77% were motorcars. It is believed that the number of vehicles will grow by 1-3% yearly. This outlook can be reviewed in several of Tallinn's development plans [33].

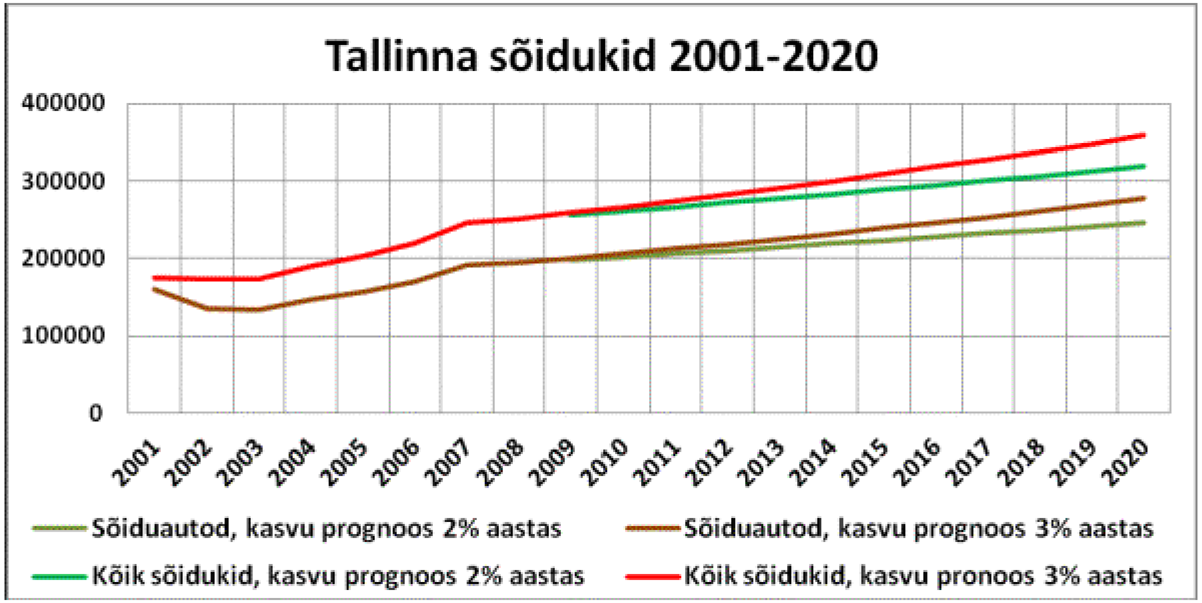

Figure 14. Outlook for the number of vehicles in Tallinn

[Title of the diagram: vehicles in Tallinn 2001-2020. Dark green line: Vehicles, growth outlook @ 2% per year. Green line: All vehicles, growth outlook @ 2% per year. Brown line: Vehicles, growth outlook @ 3% per year. Red line: All vehicles, growth outlook @ 3% per year].

Figure 14 "Outlook for the number of vehicles in Tallinn" illustrates the number of vehicles in Tallinn from 2000 to 2009 and the prospects for their growth by 2020. The most likely growth is believed to be 2% per year, and, as a result, the number of vehicles in Tallinn 2020 will be 320,000, of which 246,000 will be private motorcars (the increase is 27%).

At the same time, all possible measures are to be taken to reduce the amount of fuel consumed in the transport sector. For this purpose, vehicle manufacturers have started to work out and develop vehicles based on biofuel with lower fuel consumption.

The European Union Directive[34] has stipulated requirements with regard to the development of environmentally friendly and energy-efficient vehicles. The Directive prescribes that upon the delivery of motorcars it is essential to consider all potential life-cycle costs and supply motorcars with the smallest overall costs. As a result, the total amount of fuel consumed in transport sector by 2020 should not exceed that of 2007. According to the Action Plan, with the application of all energy-saving measures the total demand for transport fuel in Tallinn 2020 must remain at the same level as 2007.

3.3.5. Fuel consumption in the transport sector

Fuels consumed in the transport sector is being reviewed in compliance with the above-mentioned development scenario, provided that the fuel consumption remains at the same level as in 2007: however, 10% of the fuel consumed in the transport sector will be biofuel. The share of public transport in the fuel demand will also increase. The consumption of petrol and diesel fuel oil is going to decrease by 10%. Table 14 "Fuel consumption in the transport sector in Tallinn 2007 and outlook for 2020" provides a review of fuel consumed in the transport sector in 2007 and the corresponding 2020 outlook. In 2020, the total consumption of motor fuel will be 307,000 tons or 3615 GWh.

Table 14. Fuel consumption in the transport sector in Tallinn 2007, and outlook for 2020

	Consumption 2007			**Consumption 2020**		
Fuel	(th t)	(GWh)	(%)	(th t)	(GWh)	(%)
Diesel fuel oil	156	1,838	50,8	141	1,664	46,0
incl. urban transport	9	101	2,8	10	118	3,3
Petrol	126	1,535	42,5	113	1,379	38,1
Light fuel oil	21	242	6,7	18	212	5,9
Biofuel	0	0	0	35	360	10,0
Total	**302**	**3,615**	**100**	**307**	**3,615**	**100**

Most transport fuel will still be diesel fuel oil and (auto-) petrol (see Figure 15 "Outlook for transport fuel consumption in Tallinn 2020"). The share of biofuel in vehicular fuel consumption is set to increase by up to 10% by 2020, mainly in the field of urban transportation.

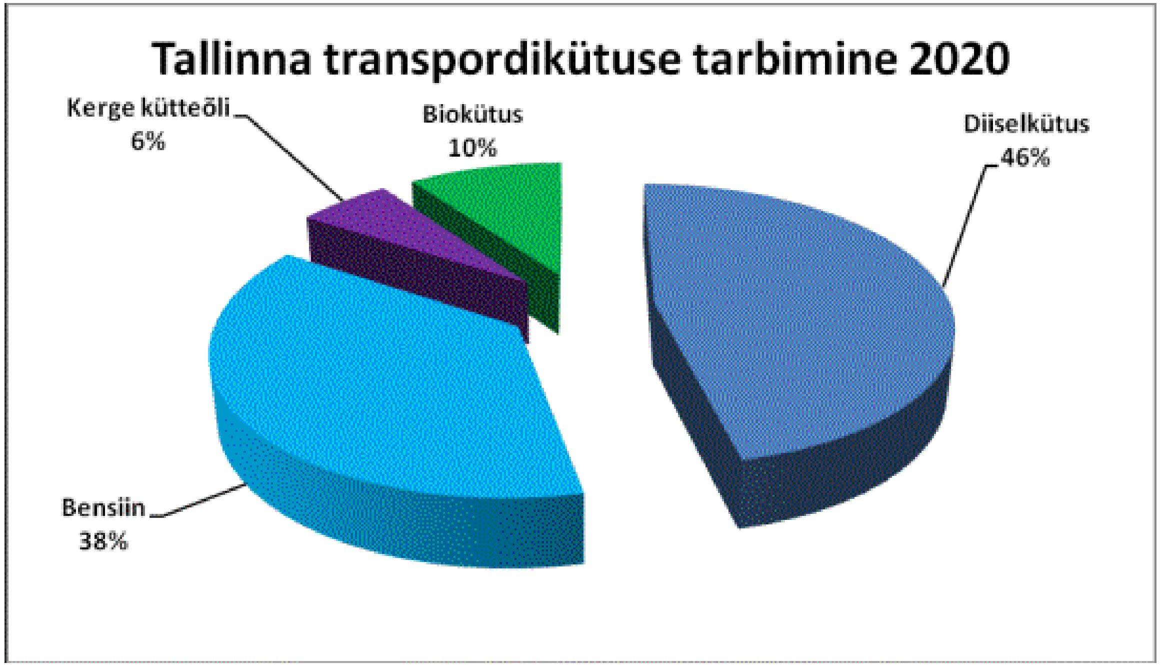

Figure 15. Outlook for transport fuel consumption in Tallinn 2020
[Diagram title: Transport fuel consumption in Tallinn 2020. From left to right: Petrol, Light fuel oil, Biofuel, Diesel fuel oil].

In addition to motor fuel, such transportation modes as trams, trolleys, and electrical trains consume electric power. Tram and trolley traffic offers services in the Tallinn area. In the transport sector, the share of consumption of electric power as part of the total amount of fuel and energy consumed is going to increase, due to the development of public transport generally and the construction of the tram line in Lasnamäe district.

The share of the known fuel and electricity costs of urban transport as part of the total amount of energy consumed by the transport sector (in energy measurement units), which in 2007 comprised only 3.5%, is going to increase by up to 5%.

3.4. Street lighting

Tallinn's outside lighting, which consists mainly of street lighting, has seen considerable development over the last decade.

In the last decade, the total number of outside sources of light in Tallinn has increased 1.6 times (see figure 16 "Number of sources of light in Tallinn"), while the electric power demand of street lighting has remained at the same level. The reason is the implementation of light sources with a higher capacity. In 2007, the number of light sources in the streets reached 40,000. Tallinn's streets are well illuminated so there is no need to add a considerable number of light sources in the coming years. The electric power demand of street lighting is not expected to increase either. Better illumination performance is being achieved by more efficient allocation of light sources and the development of technical solutions.

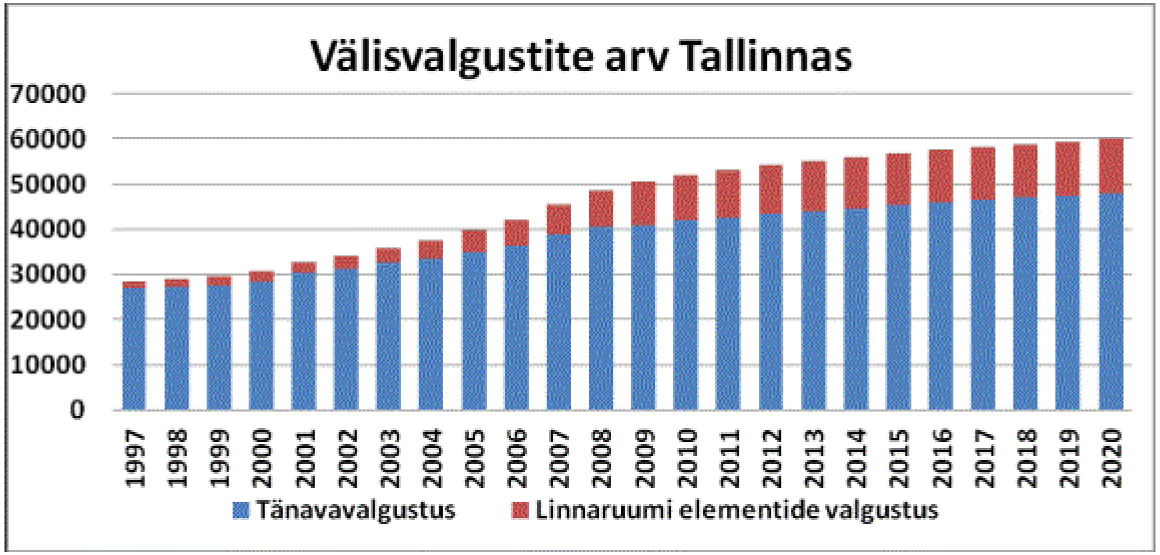

Figure 16. Number of sources of light in Tallinn

[Blue line: Streets lighting. Red line: Illumination of the elements of urban design].

The technical level of the control systems of Tallinn's street illumination has been thoroughly sorted out to ensure proper regulation. Outside lighting is controlled by the electrical engineering company KH Energia-Konsult Ltd, located on Laki Street. We need to proceed with the development of local control systems for outside lighting. Economic expediency is the main restraint on the implementation of the simplest solutions. If keeping such a control system turns out to be more expensive than the total amount of electric power saved then the use of such a system does not make sense.

The other essential trend is the implementation of light sources with higher capacity. In modern Tallinn, all the old mercury lamps have been replaced with more efficient high pressure sodium lamps. With the construction of new street lighting systems and the reconstruction of the existing streets, it is vital to implement new technical solutions using more efficient light sources and systems that regulate the operation of street lighting.

Energy-saving opportunities for streets lighting.

Efficiency is being achieved through the reduction of the energy demand of light sources and the extension of their lifetime.

1. **Usage time reduction** – it is rational to limit the operation of outside lighting in the early morning with its low-density traffic flow. As to the reduction in operating times, road lighting standards must be taken into consideration.

2. **Regulation of light sources' capacity** – it doesn't make sense to keep lights operating at full capacity all night long. It is possible to reduce their capacity by 50% at some times. This solution will still secure sufficient illumination for passers-by at night-time, and will enable the saving of energy in a simple way without the need for big investments. To ensure safety it is possible to regulate the level of illumination at night-time in accordance with the volume of traffic and weather conditions such as rain, fog, snow, and cloud cover. However, such a system capable of automatically controlling the level of illumination takes a lot of investment. Besides, energy efficiency cannot be precisely proportional to the reduction in illumination.

3. **Reduction in the number of lights** – advanced lights are being installed as part of the construction of new street lighting systems and the reconstruction of the existing streets, enabling a reduction in the total number of light sources without a decrease in the density of light.

4. **Replacement of inefficient lights** – efficient lights allow energy costs to reduce without detriment to the quality of the density of light. This includes replacement of old lights which are not equipped with reflectors with new light sources having better capacit.

The use of LED-lights could be one of the possible trends. This year several companies are installing LED-lights on Põhja-Tallinn's Stroomi territory in order to control their efficiency and durability. The current technical level and durability of LED-lights is not enough for their further widespread implementation.

Besides, a widespread implementation of LED-lights is still quite expensive. 50–150W lights cost from 5,000 to 10,000 kroons. Their price will fall due to technical development and widespread implementation. LED-lights have to become of higher quality and more durable in order to promote their active implementation for street lighting.

Tallinn's street lighting in 2007 and 2020 shows the following proportions:

	2007	2020
number of outside lights	45,000	60,000
average unit capacity of each light	192W	156W
street lighting gross power	7,500MW	7,500MW
street lighting energy demand	30,000MWh	30,000MWh

The reduction of the average unit capacity can be achieved through the use of lights with much better illuminative power, mainly on new and reconstructed roads. The amount of electricity consumed by street lighting can remain at the same level, or even decrease, despite the increase in the number of lights, provided that lights are used in the economy mode using little electric power and high light efficiency.

3.5. Water resource management

AS Tallinna Vesi is the major enterprise in the management of Tallinn's water resources and is considered to be the biggest electric power consumer in the city, using 2% of Tallinn consumers' electricity. Therefore it is essential to seek out energy-saving opportunities for Tallinn's water-supply system. The rate of electricity consumption in the water treatment system has decreased in recent years due to the implementation of pumps with higher power efficiency and control systems equipped with frequency converters. This trend is to be proceeded with in the coming years.

The rate of electricity consumption in sewage treatment has increased to a some extent due to technological advances. In this field it is vital to use biogas energy to the fullest extent and install new gas engines using biogas for heat generation. It is also necessary to study and minimise the electricity consumption of separate devices and systems.

It is impossible to save a significant amount of electricity in the maintenance and improvement of the technical level of water purification and sewage treatment systems. That is why it is necessary to pay special attention to the consumption of secondary energy. Energy-saving consumption requires the following measures:

- implementation of modern equipment (pumps with higher power efficiency, pump control systems, pump control systems equipped with frequency converters);
- the maximum use of biogas produced in the course of wastewater treatment, - installation of a new gas engine for the generation of electricity and heat;
- use of solid waste as a fuel.

From the energy point of view, it is most efficient to make use of wastewater residual heat by means of a heat pump, and further transfer the produced heat to Tallinn's district heating network. The required investment in this project amounts to 150-180 million kroons, and the volume of heat that could be produced annually is 100–120GWh; as for the cost of associated electric power, its one third of the energy produced. Performance capabilities of heating plant based on wastewater residual heat are available in paragraph 3.2.4 "Use of wastewater residual heat."

3.6. Waste treatment

The Estonian National Waste Management Plan 2008 - 2013 was adopted by the Estonian Government in May 2008. It is targeted at the further organisation of waste management in Estonia, enabling it to fulfil its obligations to the European Union in regard to the waste treatment issue, and to develop an environmentally friendly and optimised waste treatment system that would be applicable across Estonia.
According to current estimates, household waste (together with packaging waste) contains 60-65% of biodegradable waste. At a rough estimate, household waste going to landfills contains the same amount. The National Waste Management Plan and environmental impact assessments provide an analysis of various waste treatment scenarios, in accordance with the requirement to decrease the proportion of biodegradable waste in household waste deposited in landfills, (the percentage of biodegradable waste in the total amount by weight of household waste going to landfills must not exceed 45% by 16 July 2010; 30% by 16 July 2013, and 20% by 16 July 2020, respectively (Waste Act RT I 2004, 9, 52)).

Composting of biodegradable waste can contribute to the reduction of its contribution to landfill. The collection of biodegradable waste is one of the most expensive stages in the whole treatment process. The success of the composting process depends on the quality of the raw material. Composting of biodegradable waste can be done in waste plants (In Estonia 2007, there were 29 such plants, while 100 was the number needed). Composting technology depends on the raw material, its quantity, and the location of the waste plant.
In order to fulfil the biodegradable waste treatment requirements, one has to compost or digest waste which has gone through a preliminary separation process, to implement the mechanical biologic treatment (MBT), or to incinerate household waste (mass incineration).

In the case of incineration, the investment necessary is 2.5 billion kroons, as calculated by the Estonian National Waste Management Plan. Waste incineration contributes to the reduction of both the amount of waste in landfill and the emission of landfill gas (including greenhouse gases) into the atmosphere. Waste incineration, instead of storage in landfill, reduces greenhouse gases emissions, the impact of which can be comparable with CO_2 emission into the air. Waste incineration also reduces the rate of fossil fuel consumption and the amount of the corresponding contaminants released.
From the point of view of both environmental impact and economic costs, the most optimal waste management scenario would be one when a possibly large quantity of household waste is recycled or incinerated with the aim of producing energy. An important benefit is that the above scenarios allow the fulfilment of intentions set by the Waste Act in regard to both packaging waste and biodegradable waste[35]. The city of Tallinn has worked out Tallinn's Waste Management Plan, which sets goals for the development of waste management and stipulates guidelines for the period from 2006 to 2011. Today preparation of the waste management plan for the next period is being made.
Tallinn's Waste Management Plan 2006-2011 has been designed to provide analysis of the current waste management situation as well as to set liabilities and objectives in compliance with legal acts, and work out general objectives and action plans for Tallinn's waste management system. Tallinn's Waste Management Plan is based on both the Estonian National Waste Management Plan 2008 - 2013 and Harju County Waste Management Plan, and also on the renewed provisions of the Waste Act adopted by the Republic of Estonia.

Tallinn's Waste Management Plan 2006-2011 aims to reduce the amount of waste going to landfill and to increase the amount of waste recovered by way of recycling materials, including the target set to recycle 30-40% of household waste by 2009. The Waste Management Plan also stipulates the development of waste fuel production, and the investigation of opportunities for waste fuel use as well as checking the possibilities of incinerating waste and waste fuel.

The purposes of Tallinn's Waste Management Plan for the following period (10 years and further) include reduction of the total waste quantity in Tallinn's landfill through the implementation of new waste treatment systems and the enhancement of waste recycling project development. Long-term purposes of Tallinn's Waste Management Plan are as follows:

- sorting and recycling of waste materials and waste fuel preparation;
- implementation of waste and waste fuel incineration;
- reduction of waste quantity and an increase in the recycling process. The long-term purpose dictates that the percentage of the recycled waste materials will be over 50%.

The Estonian Environmental Strategy until the year 2030 has set the following priorities in regard to the waste management organisation procedure:

1) waste prevention;
2) reduction of both waste generation and its degree of hazard;
3) waste sorting and recycling;
4) increase in the quantity of waste to be recovered;
    - direct circulation (re-use);
    - material circulation;
    - biological process (composting);
    - energy recovery (waste incineration to produce energy);
5) waste treatment in compliance with environmental requirements;
6) elimination of the environmental impact from waste disposal.

The above purposes are to be reflected in the new Tallinn waste management plan which is being prepared for the following period.

The main provision of the European Union Waste Directive in regard to waste recycling is that the appropriate measures are to be taken to secure the recovery of both raw materials and energy in order to minimise the ultimate waste quantity going to landfill. Priorities related to waste recycling have been set as follows: re-use, waste recycling as a material or raw material, energy recovery (incineration)[36].

SEI Tallinn Centre has investigated waste management[37] in order to estimate and compare possible household waste treatment scenarios (waste recycling, composting, incineration, deposit in landfills) both at the global and local levels, to inform the implementation of the waste treatment hierarchy in Estonia. In addition, economic costs for selected waste treatment procedures have been estimated at a general level. The probable establishment of waste incineration plant has to be handled both at the national and regional levels.

In Estonia, two waste incineration plants (in Tallinn and Tartu) are to be established in accordance with the waste incineration scenario research, and the vast majority of household waste is to be incinerated. In order to achieve the recycling targets set by the legal acts, about 24% of household waste materials has to be recovered by way of recycling. Provided that big cities use central waste collection and treatment systems to some extent, then at least 10% of household waste could be recovered through biological recycling. Considering the intended capacity of waste incineration plants (in Tallinn it will be 220,000 tons, in Tartu 100,000 respectively), most household waste could be transferred to the incineration plants. The remaining household waste could be deposited in landfills.

The research results proved that the recycling of reusable materials contained in household waste (mostly metal and packaging waste), as well as household waste incineration along with the production of heat and electric power are efficient waste treatment modes. Incineration has a positive impact on the environment since it contributes to the reduction of the use of fossil fuels (primarily oil shale) and the contaminants that they correspondingly release.

Apart from the fact that the above waste treatment modes become an additional source of energy, the value of which is continuously growing, they also bring economic profit. The collection of waste and recycling of reusable materials has a positive impact on the environment. However, the economic costs for waste recycling processes in many ways depend on the organisation and efficiency of the waste collection system[38].

OÜ Tallinna Biojäätmed is developing a project which aims to increase the energy potential and recycling of biowaste in the area of Tallinn and Harju County. The project is being carried out on the area of the Jõelähtme Landfill. The aim of the intended pre-treatment facility is to remove unwanted impurities from household organic waste and biowaste from industries, separately collected, in order to make it possible to use the material in biogas stations.

The planned capacity of the whole facility is 15,000-20,000 tons of biowaste per year. The project is scheduled to be completed in 2011/2012, and the initially estimated total cost ranges from 38-40 million kroons. In 2009 AS Tallinna Prügila put into operation process flow for the production of fuel from waste on the Jõelähtme Landfill site. Accordingly 80,000 tons of waste are treated there annually producing 40,000 tons of waste fuel (RDF), which are then used as boiler fuel. In spring 2011, Ragn-Sells AS, the waste handling company, is planning to set up a waste incineration plant in Tallinn on Suur-Sõjamäe Street which will cost 200 million kroons. Currently an environmental impact assessment is being made in regard to this project. The plant's working capacity is estimated at 80,000 tons of mixed household waste and 10,000 tons of industrial and construction waste per year provided that the plant runs two shifts.

Moreover, Tallinna Prügila AS plans to establish power and heating plant on the site of the Jõelähtme landfill using biogas in the gas engine. The electricity capacity of the intended plant amounts to 1.9MW, and the project is to be completed by 2010.

Table 15. Waste management challenges 2010–2020

Activity	Quantity of treated waste (th t)	Produced energy (GWh)	Responsible party	Investment (million kroons)
Waste sorting and waste fuel preparation	40–100		Ragn Sells AS AS Veolia Environmental Service	200–300
Waste-to-energy plant	100–200	130–310	Eesti Energia AS	1500
Waste composting	15–20		Tallinna Prügila AS	20–40
Use of landfill gas	All waste deposited in the landfill	15–30	Tallinna Prügila AS	10–20

The realisation of the above opportunities will enable the intended waste treatment target to be achieved, and to use waste for energy production.

3.7. Housing construction

More than 80% of Tallinn's housing stock has been built since 1945. The calculation of a building envelope’s thermal resistance is based on the standards of those years[39]. Considering that the energy price at that period of time was much lower, building envelopes used to have low thermal resistance, not to mention poor construction quality. Since fuel prices have a tendency to grow continuously on the world market, it is necessary to start using construction with lower thermal conductivity.

The Estonian Construction Act[40] is an important legal act which regulates construction activity and has to be followed in the construction and renovation of buildings. The Construction Act stipulates principles for the energy audits of buildings and their organisational procedures, which are especially important from the point of view of energy consumption.

3.7.1. Energy audit

An energy audit is very important in the assessment of a building's energy state. An energy audit must be made prior to any renovation of the heat source or the heating network, or prior to insulating a building, in order to find out the building's actual energy consumption.
In compliance with the Construction Act, anenergy audit is the analysis of measurements and collected data which show the rate of use of energy in a building, provides a review of a building's technical state, the rate of energy consumption and possible energy-saving opportunities and measures for improving a building's internal conditions. An energy audit contributes to the more efficient use of energy.

In addition to an analysis of heat and power consumption, an energy audit also assesses the efficiency of water use, indoor air ventilation, the state of illumination, and, accordingly appropriate proposals are made for any energy-saving measures to be taken and the improvement of living conditions (indoor air, illumination). The submission of energy-saving measures includes an estimate of both their cost and the resulting benefit. For the purposes of an energy audit the Credit and Export Guarantee Fund KredEx can provide a loan of up to 10,000 kroons to an apartment or housing association or an association of apartment owners.

In its attempts to accelerate activity relating to the implementation of energy end-use efficiency in the public sector, the Ministry of Economic Affairs and Communications along with KredEx[41] support the complex renovation of apartment buildings for improvement of energy efficiency (at least 20%), and the use of renewable energy in dwellings by making loan capital easily obtainable. For Estonia such an improvement in energy end-use efficiency would reduce economic costs by approximately 6 billion kroons per year. In Tallinn, the value of heating energy that could be saved is already estimated at 280 million kroons per year.

After an energy audit is successfully executed, a package of enhanced energy-efficient measures is proposed by which significant energy-savings can be achieved. The renovation loan can be taken only if the corresponding renovation project has been planned on the basis of the auditor's recommendations. The building company which is going to do renovation works has to be registered in the commercial register, and, prior to the construction works, the owner of the dwelling has to appoint a person responsible for supervising the work. Energy-saving methods have a long payback period due to their high building costs, however, a dwelling's renovation contributes to the economy of both the individual and the whole state, and improves living conditions. Over the whole territory of Estonia such an improvement in the efficiency of energy end-use would reduce economic costs by approximately 6 billion kroons per year. The only problem in the implementation of these measures is their long payback period and high building costs.

It is more efficient to make a complete renovation: the most critical energy-saving measures are these -

- additional insulation of building envelopes (walls, doors, windows, roof, attic ceiling, roof-ceiling, cellar walls, and ceiling), which also eliminates cold bridge problems;
- sealing or replacement of panel joints, windows, and doors, supplying windows with triple-glazing etc.;
- installation of automatically controlled heat supply stations, which enable the hydraulic isolation of the district heating network from a dwelling's heating system: heat is transferred to a dwelling's heating system by means of water circulating in a heat-exchange facility;
- regulation of a system that arranges household water heating (circulation arrangement, automatic control, replacement of an old sectional heat-exchange facility with a modern one);
- renovation of heating and ventilation systems;
- reconstruction of a joint pipe system into a double-pipe system;
- supplying radiators with thermostat valve settings and their appropriate use;
- heating system balance;
- supplying apartments with heat meters (the device does not save energy as such, but contributes to the motivation to save energy provided that all the above measures have been taken).

3.7.2. Energy passport

The energy passport is designed to show home-owners or tenants their actual energy consumption in kilowatt hours (kWh) per 1m^2 of floor area per year. The issuing of energy passports is stipulated by the legal act "Energy performance certificate and the procedure for issuance"[42].

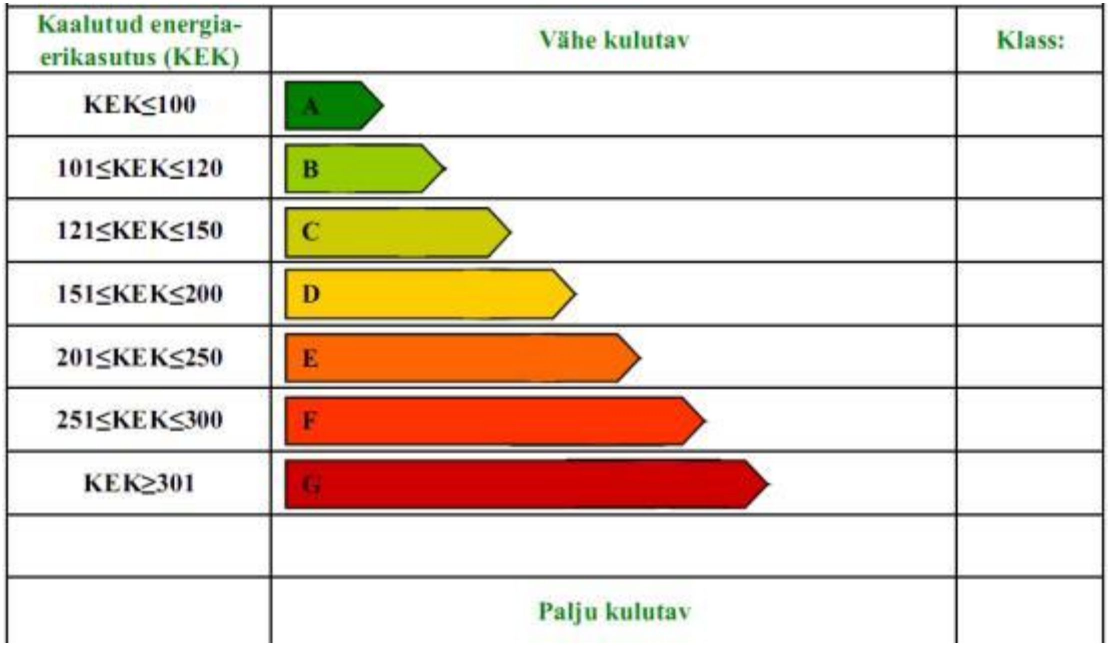

Figure 17. Energy performance certificate

[At the top of the diagram from left to right: weighted energy use; economical; class. At the bottom: uneconomical].

Since January 1, 2009, an energy passport (see Figure 17 "Energy performance certificate") has to be issued for all new buildings as well as all public buildings with more than 1,000 m² of usable space, or during the sale or rental of a dwelling when requested by a buyer/tenant. An energy passport is a document which provides data on energy consumption level in a dwelling in comparison with the average amount of energy consumed in other dwellings of equal value.

An energy passport indicates the energy efficiency ratio of an existing or planned dwelling. The higher a dwelling's energy performance class is on the scale of the Energy Efficiency Classes (from A to G), the lower is the use of power and heating. In order to encourage the owners of buildings to deal with energy efficiency problems, Tallinn City Council has issued decree nr 9 "The regulation for grants to housing associations in accordance with the issuance of energy performance certificates and training costs" as of March 19, 2009, which, beginning April 1, 2009, enables a housing association to apply to the Tallinn City property department for a grant of 1,500 kroons for each dwelling in an association to cover eligible costs related to the issuing of a corresponding energy passport.

It has to be said that the time when energy can be wasted is gone. The circle of energy efficiency measures to be implemented is continuously expanding. Minerals and timber resources have to be used in a more efficient way and it is only sensible to build energy-efficient dwellings.

3.7.3. Requirements for heat supply in dwellings

The green book on energy efficiency[43] proposes requirements for the energy supply of dwellings and makes recommendations for the more efficient consumption of energy. The Directive on Energy Performance of Buildings,[44] which has been put into effect since 2006, will allow Tallinn to save 15 million tons of oil equivalent [Mtoe] from now to the year 2020.
The European Commission aims to provide its Member States with all the necessary resources to use a harmonised method for calculating the energy efficiency rate of dwellings (30 European (CEN) standards have already been worked out).

The resolution of the Estonian Government[45] specifies and strengthens the minimum requirements for energy efficiency. This resolution allows for the planning and construction of dwellings which have a significantly lower energy demand in comparison with those dwellings built to obsolete standards. The energy performance value of newly built dwellings must not exceed the following values:

small dwellings	180kWh a/m^2
apartment houses	150kWh a/m^2

…and the energy performance value of reconstructed dwellings must not exceed the following numbers:

small dwellings	250kWh a/m^2
apartment houses	200kWh a/m^2

Thermal resistance in a dwelling is a critical factor. It is necessary to plan and construct dwellings and their heating, cooling and ventilation systems in a manner that will minimise the amount of consumed energy, taking local climate conditions into account. The construction of dwellings that are inefficient from the point of view of energy consumption is no longer allowed. There are also specifications in regard to requirements for building envelopes.

In order to maintain the thermal comfort of buildings, generally heat conductivity must not exceed a value of 0.5 W / m^2·K. In case a dwelling's windows have high heat conductivity, thermal comfort must be secured with an appropriate level of heating.

The selection of a dwelling's thermal protection should secure a good level of energy efficiency. The selection of thermal protection and energy calculations for small dwellings will be based on the following initial values:

- heat conduction of external walls 0.2–0.25 W / m^2·K
- heat conduction of roofs and floor 0.15–0.2 W / m^2·K
- heat conduction of windows and doors 0.7–1.4 W / m^2·K

At the meeting of the European Union (EU) Energy Council that took place on December 7, 2009 in Brussels, and where Estonia was represented by the Minister of Economic Affairs and Communication, Juhan Parts, resolutions were approved which expand the requirements for the energy efficiency of dwellings and specify all products that may influence energy consumption in the future.

The Directive on Energy Performance of Buildings has been amended as a result of the European Union aim to reduce the demand for primary energy by 20%, and due to the great share of total energy consumption represented by dwellings.

Estonia is mainly influenced by those changes that concern the improvement of energy use in existing dwellings and the need to increase the number of dwellings with a small rate of energy use. According to the approved amendments, the European Union Member States are to fulfil the corresponding requirements for the reconstruction of existing dwellings to the full extent, i.e., changing buildings' envelopes or advancement of technical systems. Moreover, Member States are to construct more dwellings with a small rate of energy use. The Energy efficiency of new dwellings will have been gradually improved, since, beginning in 2021, all potential dwellings are to have a small rate of energy use.

3.7.4. Energy-saving opportunities in the residential sector

Half of Tallinn's housing facilities have been built in 1960–1990. Dwellings with reinforced concrete slabs having poor thermal resistance comprise the major part of these facilities. The technical state of these dwellings, including thermal resistance, has been thoroughly investigated by scientists from Tallinn University of Technology[46]. In compliance with their estimates, the heat transfer ratio along with a cold bridge in an apartment house of bearing-wall construction is 0.9–1.2 W/m^2K. Dwellings have to be renovated and heat-insulated with 100–250 mm thick infilling. These works have been started and are to be continued in order to advance the dwellings' heat resistance.

Over the last years, there have been quite a few discussions in regard to energy-saving houses, such as ecohouses, passive houses, zero-energy homes, etc. The main common features of energy-saving houses are listed below.

- Use of environmentally friendly construction materials:
  - production of construction materials with the lowest energy costs;
  - use of natural materials that are safe for one's health;
  - use of re-usable materials to reduce load on the environment.
- Efficient, money-saving:

  The long-term use of a dwelling is efficient and money-saving in terms of maintenance expenditures, which are mainly heating expenses. Primary investment in such a kind of dwelling is 30% higher than ordinary houses.

- Possibility to stop using central networks:
  - passive solar heating – energy use;
  - use of rainwater – use of rainwater as household water;
  - wastewater treatment – local waste purification and composting system;
  - wind generator – use of wind energy.

Today, full implementation of such solutions would probably be too expensive, however, any of the above measures could perform a supplementary function.

The main distinguishing features of these dwellings in comparison with ordinary ones include better heat-insulation: wall insulation is about 45 cm, and roof insulation 50-60 cm thick. In ordinary houses, these values are half as great. These dwellings also have sufficient resistance to air permeability which enables the saving of a considerable amount of heating.

In the future, energy-saving houses will certainly become very popular since energy costs are continuously growing, and an efficient house helps its resident to save these costs. Today is the most favourable time to build an energy-efficient dwelling since building costs have fallen by 30% on average, which comprises just that particular difference with the building costs of ordinary dwellings. So today is just the right time to implement a project for the construction of an energy-efficient dwelling.

3.7.5. Renovation of facades

The project named “Let's renovate facades” is based on resolution nr. 38 of Tallinn City Council adopted as of October 15, 2009. The project “Let's renovate facades” stipulates the procedure for supporting housing associations which intend to reduce energy consumption in their dwellings.

The project “Let's renovate facades” aims to regulate targeted support of housing associations upon the implementation of projects for energy-efficient consumption. Today, the implementation of energy efficiency measures is becoming increasingly popular on account of a twofold increase in heat energy prices since 2007, and a continuing growth in prices for heating, electric power, water, and gas. Many Tallinn's dwellings are not considered energy-efficient, since the construction material used upon their construction does not meet modern quality standards; the majority of facades have lost their weather resistance.

The project “Let's renovate facades” aims to support the renovation of dwellings and improve the energy-efficiency level of small dwellings (with areas up to 2,000 m^2) by at least 20%, and in big dwellings (more than 2,000 m^2) by at least 30% respectively.

The project aims to provide support for those dwellings built before 1993 in regard to the reconstruction of the main construction (supporting structures) and renovation or replacement of heating and ventilation systems; moreover, the target of the project is to motivate housing associations to install devices based on renewable energy. The city of Tallinn helps housing associations to cover the self-financing share upon the application for a renovation loan.

The grant comprises up to 10% of the required renovation loan, but cannot exceed 300,000 kroons per year.
The general purpose of the support is to improve the energy efficiency of dwellings and reduce energy costs, which can be achieved through the implementation of the following measures:

- heat-insulation of facades;
- improvement of door and windows' heat resistance;
- improvement of balconies' heat resistance;
- improvement of heat resistance in the upper part of foundations and basement floor;
- ventilation;
- roofs;
- heating systems;
- other energy efficiency measures.

The expected benefit:

- improvement of the energy efficiency level of dwellings;
- improvement of the exteriors of dwellings;
- preservation of dwellings that are valuable from the point of view of their cultural heritage;
- enhancement of housing associations' own initiatives and co-operation;
- strengthening of social relationships in dwellings.

A housing association has to be registered as a non-commercial organisation for at least six months prior to the submission of an application for support. Applicants must not have any EBRD loan obligations to AS Tallinna Küte.

The application shall include supplementary papers, results of the energy audit, and the description of the corresponding planned renovation works, the required budget, work program, etc. The application must be submitted to the relevant local government. Since the first Monday of February 2010, subsidies are being allocated within the relevant budgetary monetary funds during the calendar year.

During the next decade, the required investment in the renovation of Tallinn's housing facilities and public buildings and the improvement of their heat resistance amounts to 2-3 billion kroons. The activity requires the involvement of the city's facilities (buildings, schools, kindergartens), private sector (enterprises), as well as residents. The implementation of the these measures could save 20% or 670GWh of the currently consumed heat per year.

3.8. Elements of urban design

The illumination of elements of urban design (farms, the Old town, monuments, non-motor pathways, and promenades) has seen a decisive breakthrough over the last decade - the number of light sources has increased fivefold. Some growth in the number of light sources is expected to take place in the coming years, however, not as rapidly as it has been. It is essential to seek out energy-saving opportunities in this respect.

3.8.1. Park lighting

Park lighting has its own special requirements for the quality of illumination - here, it is not allowed to use an inappropriate luminous spectrum. Development is being concentrated on the following trends:

- implementation of energy-saving lamps with the appropriate luminous spectrum - lamps of this kind are still being worked on, and there are no specific values;
- optimisation of lighting hours.

The optimisation of park lighting will enable a reduction in the amount of the electric power consumed, something which has greatly increased over the last years. The process of optimisation of park lighting shall be based on the corresponding statistical data on crime rates, which will be obtained in co-operation with the police.

3.8.2. Lighting of the Old town

The illumination of the Old town's streets belongs to the street lighting category. The Old town's lighting level is generally good. The Old town is mostly lit by high pressure sodium lamps, which, however, have an inappropriate luminous spectrum. The facades of separate buildings are illuminated by LED-lamps.

The growth of energy costs for the lighting of the Old town must be limited, and it is vital to find new and energy-saving technical solutions which would enable the achievement of better illumination levels without an increase in electricity costs. These solutions could include the implementation of new, energy-saving light sources and the further development of control systems.

3.8.3. Monuments and memorials

Existing technical solutions are to be further developed and new ones implemented in order to reduce the electricity demand of monument and memorial illumination. Electric power can be saved by means of directional lighting, the implementation of energy-saving light sources, and further development of control systems.

3.8.4. Promenades and easy way roads

Over the last years promenades and pathways have gone through a rapid development which is to be further continued. Many of Tallinn's non-motor pathways, including the longest non-motor and skiing pathways in Nõmme and Pirita districts, have been worked out in co-operation with Eesti Energia AS. The regulation of the lighting systems of these pathways did not cause particular difficulties: the most important task was their quick preparation. Electricity bills are paid by the city of Tallinn, so it is necessary to proceed with the development of lighting control systems that would enable the saving of electricity.

Nowadays, pathway lights operate in the evening from sunset until 11 p.m. and in the morning from 6 a.m. until sunrise. However, the question is whether these operating hours suit all weather conditions. For instance, in case of rain there’s no sense to keep lights working when there are no passers-by on a pathway.

It is also possible to regulate the operation of individual lights: on the pathways it is sensible to install lights that activate only in the presence of passers-by and illuminate that part of a pathway which is necessary for safe walking. For example, when someone walks a pathway a special motion sensor could activate the five lights in front and five behind and keep them on for a certain period.

This kind of solution would provide security for all passers-by and save some share of the energy used for lighting these pathways. However, relatively frequent power-off-power-on of lights can shorten their life-span and increase maintenance costs. This problem could be solved with the implementation of LED-lights which are quite durable in terms of power-on-off operation. In order to prevent lights from being activated by animals, the system should be fully switched off for a certain period at night.

The development of lighting of Tallinn's elements of urban design for the period from 2007 to 2020 is characterised by the following values:

	2007	**2020**
• number of light sources for elements of urban design	6,600	12,000
incl. LED-lights		8,000
• average unit capacity of each light	152W	85W
• gross power of light sources for elements of urban design	1,000MW	1,000MW

- energy demand for lighting of elements of urban design 4,000 MWh 4,000 MWh

Elements of urban design shall be illuminated by modern lights having small energy costs, but sufficient luminous efficacy, such as LED-lights; control systems shall also operate in an energy-saving mode. The implementation of new solutions with regard to the illumination of elements of urban design requires investments to be made amounting to 10-12 million kroons.

3.9. Use of land

3.9.1. General development trends in the use of land

Tallinn has a relatively high population density, since, as of 2007, there were 2,510 residents per square kilometre. Population density varies significantly depending on the city district, i.e., in Mustamäe district, there are 7,883 residents per square kilometre, while Pirita district has only 751 residents per square kilometre.

In recent years the use of land in Tallinn has become more intensive, and the degree of population has become correspondingly more dense, which must be considered in the development of energy-saving. The denser the population, the lesser area is needed for transmission, and the lesser and more trifling are network losses (in the transmission of heating, electric power, water, as well as in wastewater facilities).

At the same time it is essential to pay due regard to living conditions and comfort. The distance between a park or green field area and a dwelling shall not exceed 300m. An optimal solution is to be found taking these requirements. Into consideration.

Basically, in Tallinn, the use of land has become more intensive over the years: in the area of the city centre, free ground is being fully developed, and the existing housing is being expanded. The only available green field areas in this part of the city include the bastion belt surrounding the Old town, Kadriorg Park located on the boundary of the city centre, and the sea shore which lies along the whole territory of the city. From the point of view of both recreational opportunities and the absorption of atmospheric pollution, it is essential to develop the coastal promenade as a leisure area for Tallinn's residents.

As for the city's outskirts, it doesn’t make sense to build over these areas for the sake only of energy saving. The Pirita and Nõmme districts must keep their abundant green fields, which makes housing construction there more expensive, however, the comfort is worth it. The technical supply of these districts is to be carefully thought over. It is more logical to develop individual heating systems in these areas than the district heating supply network.

3.9.2 Use of transport area

To develope urban area and land useage, one has to to pay attention to the advancement of both the street network and the transport area related to it.

The document titled "Development Strategy for Tallinn’s mobility environment 2007-2035" defines the four most important strategic guidelines:

- Land use planning;

- Demand of residents for transport services and preferred transport modes;
- Effective traffic management and infrastructure;
- Road safety and environmental protection.

Guidelines for the use of land involve the arrangement of economic and social functions in a manner that secures good transportation of residents to places such as work, school, service, shopping or cultural centres, etc.; it also aims to secure such efficient operation of the public transport as would guarantee quick access to various destinations. The most preferable mode is a varied choice of saccess to goods and services in a polycentric urban region. These regions should encourage the use of such mobility modes as walking and cycling, and secure the simple organisation of public transportation. In this connection, integrated land use and transportation planning is the key to obtaining a sustainable transport system.

Land use principles are the following:

1. Multifunctional residential areas (to ensure quick access to everyday service activities):

   1.1. The enhancement of walking, cycling, and the use of public transport as the primary means of access to goods and services;

   1.2. Residential areas located within the area servicxed by public transport (mainly rail);

   1.3. That the development of conurbations and the city area is automatically accompanied by the provision of public transport (including financing its expansion) and facilities for non-motorised traffic.

2. Integrated planning of the transportation system and land use of in the conurbation, and the development of energy-saving and efficient projects in respect of the whole society.

3. The quality of the area of the city is to become significantly adanced, safe, and healthy.

When planning urban transportation it is necessary to bear in mind two requirements that may on the face of it seem contradictory; and an optimal solution is to be found in this respect.

1. Travelling within the city to the destination (for instance, to a place of work or home) is to be as comfortable and safe as possible. This requires the organiation of a good road network.

2. The city must have enough room and green areas, and motorcars must not obstruct the free movement of passers-by.

An optimum solution of these two requirements could save both the time spent on travelling and the fuel consumed.

From the point of view of the city development and . optimum energy use, the planning of land use will enable the saving of a lot of energy and turn the city into a people-friendly one.

- Optimum land use and the economic planning of the city allows the reduction of the fuel consumption of the transport sector by 5–10%.
- The rational planning of buildings – for instance, a rational improvement of high-rise residential buildings with district heating networks enables the reduction heating network losses and saves heat.
- When planning new residential areas the energy supply issue has to be thoroughly worked out.

3.10. Consumption habits

The formation of consumption habits plays a significant role in an efficient energy use. It includes both the implementation of technically advanced appliances and their rational use.

Firstly, from the point of view of energy saving, it is sensible to switch off electrical appliances not in use, and not to leave them in a standby mode. Consumers are used to leaving frequently used electrical home appliances in standby mode, rather than switch them off and disconnect from the electric mains. As mentioned above (see the paragraph 2.10 "2.10. Consumption habits"), electric power demand of those appliances that are usually left in standby mode comprises 10% of the whole electric power consumption of an average family. By switching off those appliances that are not in use at any particular moment (computers, radios, televisions), it is possible to save up to 10% of electric power.

The use of energy-saving lamps is the second opportunity for the reduction of electric power demand in a dwelling. These lamps have the same electrical capacity, but their light efficiency is 2-4 times higher than that of ordinary ones. At the same time, the production of incandescent lamps is about to be discontinued in the coming years, and the change-over to energy-saving lamps is to take place.

In Europe, including Estonia, on average a resident uses 14% of his or her electric power on room lighting. The implementation of energy-saving lamps will allow us to reduce total electric power consumption by 5-10%.

The use of appliances with low electric power demand is the third essential opportunity for electricity saving. When choosing new home appliances, it is reasonable to prefer those having energy efficiency class "A" as the most efficient one.

The fourth measure to save electric power is the use of electric appliances in a power-saving operational mode. Many enterprises and private consumers leave their computers in full operational mode for the whole night. The electric power demand of one desktop computer is 100–150W or hundreds of kilowatts for the whole City Government's computers. Computer software companies must prevent this needless use of electric power. Modern computer programmes allow an administrator to set them and take other actions to turn on computers for a short time only. This enables the saving of hundreds of kilowatt-hours of electric power. At the same time, it is sensible if possible to use laptops, since their electric power demand is five times less than that of an average desktop computer.

The insulation of buildings is one of the most important energy efficiency measures. As mentioned above, the renovation of a building enables an energy saving of at least 30%. These measures definitely require technical calculations to be made, the preparation of a project, and its appropriate execution.

Traffic habits are also significant from the point of view of energy consumption. Tallinn has a quite good non-motorised road network. In 2010, the length of non-motorised roads comprised 167.4 km. These roads suit cycling and other sports well. It is important to encourage residents to use non-motorised roads for their daily travelling, i.e., going to work or to shop. Cycling should turn into an everyday habit of Tallinn's residents. This will contribute to both the reduction in the use of motor vehicles and the demand for fuel, mainly that of private vehicles. Definitely, the promotion of non-motorised roads is to be further continued; it is necessary to make them safe for cyclists, especially in the region of highways and crossroads, to provide parking for bicycles, and in other ways make cycling an attractive alternative to car transport.

Public transportation is to become more available and comfortable. For this purpose it is necessary to pay attention to the revision of routes and the traffic density of public transport lines and make the changes needed to comply residents' needs. The purpose is to make public transport an attractive alternative to the use of private cars.

These are the most important energy-saving opportunities to be applied daily. Besides, it is very important to raise the awareness of residents of these measures and form appropriate consumption habits.

To this end it is necessary to implement the following measures:

- To organise energy efficient days to clarify and explain to residents how they can consume less energy;
- To start the promotion of energy-efficient living among schoolchildren;
- To provide entrepreneurs with training for the development of energy efficiency measures in their enterprises;
- To introduce new devices with a low rate of energy demand;
- To introduce energy-saving opportunities via radio, television, and advertising;
- To provide recognition and reward for achievements in the energy-saving field.

The City Government has a significant role in raising people's awareness and the formation of appropriate consumption habits. The changing of consumption habits allows the saving of 15-20% of energy by using the simplest measures and lowest expenditures.

4. Action Plan for Energy Efficiency for the next three years

On the basis of the present Action Plan, the previous paragraphs provide an analysis of the actual energy consumption and outlook for the development programmes. The Action Plan defines the further development of energy generation, energy consumption, the city economy, and formation of appropriate consumption habits. The Action Plan is based on the task stipulated by the European Union Directive on the development of energy economy, as well as on the objectives which have been set by the legal acts of the Republic of Estonia. The Action Plan for Energy Efficiency for the next three years has to ensure the reduction of energy consumption in Tallinn by 20% by 2020 as compared to 2007, the increase of the share of renewable fuel in energy production by 20%, and the reduction of CO_2 emissions into the atmosphere by 20% respectively.

The Action Plan for Energy Efficiency for the next three years prescribes the following four development trends:

- **Organisational energy efficiency measures**
  - Organisation of energy efficient days
  - Training for entrepreneurs
  - Energy saving in every enterprise
  - Indication of energy efficiency measures in every development programme
  - Improvement of co-operation between departments
  - Appointment of posts and officers responsible for the implementation of energy efficiency measures
- **Energy saving measures in the electricity sector**
  - Replacement of outdoor lights with new, energy-saving ones
  - Use of energy-saving lamps by both private consumers and enterprises
  - Further advancement of outdoor lighting control systems
  - Renovation of Elering OÜ tie-stations and trunk lines
  - Renovation and further development of the city's distribution networks
- **Heat supply to buildings**
  - Energy audits, thermographic investigations and the issuing of energy performance certificates
  - Renovation and insulation of dwellings
  - Construction of dwellings with higher thermal resistance

- Expansion of the use of heat pumps, especially in areas with a low population density
- Use of solar energy
- Renovation of district heating networks and replacement of pipelines with pre-insulated pipes

- **Technical development**
  - Connection of the heating networks between Eastern and Western districts in Tallinn
  - The maximum use of electric power generated in Tallinn Power Plant from biofuel
  - Organisation of waste management and the potential establishment of waste-to-energy plant
  - Renovation of boiler-houses and construction of local power and heating plants
  - The maximum use of biogas and wastewater residual heat in the sewage treatment plant
  - Implementation of biofuel refuelling
  - The further development of public transport and construction of the tram line in the Lasnamäe area

Basically, organisational and technical energy efficiency measures are closely related and supplement each other. The Action Plan for Energy Efficiency for the next three years defines measures to be taken to fulfil Tallinn's obligations in regard to energy saving in the following decade. The above four groups of measures and the potential energy-saving volume are thoroughly analysed below.

4.1. Organisational energy efficiency measures

Organisational energy efficiency measures are the first of the list of probable measures to be taken. Due to the current complicated economic climate and investment opportunity limitations, it is possible to apply only those organisational measures which involve the smallest financial resources and allow the achievement of a significant energy saving.

4.1.1. Organisation of energy efficient days

The main purpose of energy efficient days is to make residents aware of simple and efficient energy-saving opportunities. The switching off electrical appliances rather than leaving them in standby mode allows the saving of 10-15% of electric power. The experiment which carried out by the Estonian Television proved that it is feasible to save electric power in a very simple way. The broadcaster asked their television audience to turn off all unnecessary electrical devices at that time and switch off all unneeded lights, resulting in the reduction of ther electrical load in Estonia by 15%. It is necessary to ensure that each consumer realises how much energy can he or she save in everyday life.

The initiative to organise energy efficient days belongs to the City Government. The event involves the co-operation of both media (newspapers, magasines, radio, and television) and other advertising. Each consumer must be aware of the information on energy-saving opportunities. Energy-saving recommendations will be introduced in schools, enterprises and recreation centres as well as to elderly residents.

If each consumer cuts down on energy consumption and saves several tens of kroons monthly, then electricity consumption in Estonia will reduce by 10%, Estonian power plants will reduce their use of oil shale by a million tons per year, and the amount of CO_2 emissions into the atmosphere will reduce by up to one million tons correspondingly.

4.1.2. Training for entrepreneurs

The main purpose of this training is to advise entrepreneurs how to best use energy-saving opportunities in the course of production processes and offices. Some consumers customarily, or are even obliged, to leave their computers in full operational mode overnight, leading to heavy expenses for electric power, although it is not technically necessary in most cases.

Modern computer programmes allow an administrator to set them and take other actions to turn on computers for a short time only as necessary.

It is vitral to bring to the attention of entrepreneurs the problems arising with internal conditions which do not merely mean a warm room but fresh air and comfort too. Much depends on the promotion of ventilation systems and the use of air heating controls.

The second important trend involves the implementation of energy-saving technologies and appliances. The replacement of old production equipment and its engines having low power efficiency with new and advanced ones enables the saving of a lot amount of energy. It is very efficient to keep continuous control over the equipment and frequency converters to regulate the speed of engines. All these well-known facts and opportunities are introduced to entrepreneurs within the framework of training.

4.1.3. Energy saving in every enterprise

After entrepreneurs have been introduced to, and informed about energy-saving opportunities, it is essential to ensure that the said measures have been successfully taken up enterprises. The City Government must be the first to give a lead in energy-efficient behaviour by using their computers in the optimum operation mode, implementing energy-saving illumination, and finding better solutions to create a comfortable internal climate in the building. Energy-saving activity must reach every enterprise, especially those that modernise their production processes. It is essential to implement energy-saving technologies.

4.1.4. Indication of energy efficiency measures in every development programme

Tallinn has plenty of development programmes in regard to both the improvement of the city's districts and the city economy (see the List of References), however, often these programmes suffer from a lack of due attention to the development of saving energy economies. Some of these programmes do not even mention any aspects of energy economy.

Each and every development programme is to involve energy economy subjects, whether i concerns the development of the city's district or reconstruction of park facilities. A development programme must not only indicate the energy supply subject, but also provide a comparison of energy demand level prior to and after the implementation of the measures indicated indicated. The simple statement that a new solution is going to increase or decrease energy consumption is not enough. A development programme must illustrate energy saving measures and technical opportunities.

4.1.5. Co-operation between departments

The city must co-ordinate co-operation between entrepreneurs and local governments within the framework of the promotion of energy saving measures in order to avoid a situation where work on the implementation of one and the same energy saving measure is duplicated in several departments, or follow totally opposite directions, which is even worse. The City Government has a significant role in setting the activity of both the city's subordinated authorities and private enterprises and organisations.

4.1.6. Parties responsible for energy saving

The City Government shall appoint specialists for different departments who will be responsible for energy economy and energy saving issues. The city is to have an Energy Department, or, at least a power engineering specialist who will co-ordinate and take control of the city's energy economy performance.

The implementation of organisational energy saving measures requires that the lowest expenditures be incurred. An efficient and successful implementation of the said organisational measures enables the saving of 2-3% of energy annually as soon as in the first three years, and secures the fulfilment of the 20-20-20 commitment by 2020.

4.2. Energy saving measures in the electricity sector

As mentioned earlier, each consumer can do much to save electric power. A review of energy saving measures that can be taken by enterprises, departments, and electricity consumers is shown below.

4.2.1. Replacement of outdoor lights with new and energy-saving ones

As mentioned earlier, Tallinn Municipal Services Department and the electrical engineering company KH Energia-Konsult Ltd have performed good work on the modernisation of Tallinn's outdoor lighting. In recent years, 2000-3000 lights have been replaced or newly installed annually. The majority of outdoor lights have been replaced with high pressure sodium lamps. Today, there are only some hundreds of mercury discharge lamps left. Old inefficient lights are to be replaced alongside the reconstruction of streets and junctions. Only energy-saving lights are to be used in outdoor lighting.

4.2.2. Use of energy-saving lamps both by private consumers and entrepreneurs

Thew use of energy-saving lamps allows the reduction of electric power demand by 2-4 times without any deterioration in light efficiency. Besides, this year, European Union Member States have discontinued the production of 100W incandescent lamps, and by 2020 their production is to be fully closed. The implementation of energy-saving lamps will allow everyone to save a considerable amount of electricity in each house-hold. The manufacturers and suppliers of bulbs also have to be directly involved in the use of energy saving light. It is impossible to achieve energy saving to the fullest extent if energy saving bulbs are installed in out-dated fittings.

4.2.3. Further advancement of outdoor lighting control systems

Tallinn Municipal Services Department and the electrical engineering company KH Energia-Konsult Ltd have done good work on the modernisation of the city's outdoor lighting control systems, and, today, Tallinn's outdoor lighting control systems are up to the latest world standards. The development of outdoor lighting and both central and local control systems is to be proceeded with.

The majority of Tallinn's outdoor illumination operates in the evening hours after sunset and in the morning hours until sunrise, which amounts to more than 4,000 hours a year. Sufficient street illumination is defintrely necessary in the evening and morning hours, however, night-time illumination should run an optimum operational regime. Today, some street lighting is switched off in the early morning hours. It is essential to develop systems which would secure optimum outdoor illumination with the lowest electric power consumption.

Tallinn Municipal Services Department bears responsibility for the quality of the city's outdoor lighting and its operation. Considering the limited budgetary funds, in 2009, Tallinn saved 10% of actual electric power as compared to 2007, due to an energy-efficient operation mode of outdoor lighting. The implementation of outdoor lighting optimum control systems allows the saving of a remarkable amount of electric power in the future.

4.2.4. Renovation of Elering OÜ tie-stations and trunk lines

Over the last years, Elering OÜ has renovated several important substations which supply heat to Tallinn, i.e., Harku, Veskimetsa, and Kiisa substations. The replacement of several urban 110 kV overhead lines with cable lines, as well as the renovation of the Aruküla and Volta substations are planned to be completed within the next three years. The renovation of substations and lines reduces power transmission losses and enhances the electricity supply level. The organisation and financing of projects are performed by Elering OÜ, but the city may lend support to the planning and co-ordination of works.

4.2.5. Renovation and modernisation of the city's distribution networks

Some old residential areas in Tallinn, such as the Old Town and Kopli districts, still face the situation where electric supply networks at voltages of 220V and 380V co-exist in the nearest neighbourhood. It is planned to transfer the whole city distribution network to a 380V voltage system which will enable the reduction of network losses and enhance the electricity supply level. The project is to be performed by Eesti Energia Jaotusvõrk OÜ (Distribution Network). Some buildings with 220V electricity supplies belong to the city; in this case, the city itself wil order the construction of a new electricity supply system. As for the buildings that belong to private owners, the city will offer them due co-operation and support.

The implementation of the above energy saving measures in the electricity sector will allow a reduction in electric power losses and the city's general electricity expenditures by 10-20%.

4.3. Heat supply to buildings

Heat supply to buildings is one of the most important opportunities for energy saving. This issue must be handled by all buildings' owners, as well as upon the construction and renovation of buildings belonging to the city's property. The renovation and heat-insulation of the existing buildings enable to save up to 30% of energy. New buildings are to be constructed in compliance with the requirements of the EU Directive. Heat supply to buildings must be executed in accordance with the energy saving measures as provided below.

4.3.1. Energy audits, thermographic investigations and energy performance certificate

An energy audit must be done prior to the renovation of a building. An energy audit assesses the actual energy consumption of a building, indicates its problem areas, and proposes solutions for the most efficient energy savings. An energy audit is accompanied by thermographic investigations which can help to check the thermal resistance quality of a building envelope and indicate problem areas.

An energy performance certificate is designed to indicate the actual energy consumption of a building. An energy passport is obligatory for all new buildings, necessary for those buildings being demolished, and recommended for all other buildings. The execution of the energy audit, thermographic investigation, and obtaining of the energy passport are the obligations of the building's owner. The corresponding investigation and financing of those buildings that belong to the city shall be organised by the city. Energy audits and energy passports contribute to more efficient energy-saving renovation works.

4.3.2. Renovation and insulation of dwellings

Renovation contributes to both the improvement of living conditions in a building and a reduction in heat losses. It is essential to perform the necessary technical calculations and draw up the project prior to renovation works. Adherence to project conditions secures a better result of the works and the maximum energy saving.. A building renovation along with all corresponding supplements must be handled by the building's owner, i.e., the city, an enterprise, a housing association, or a private owner. The city may lend support in terms of execution and financing of these works.

4.3.3. Construction of dwellings with higher thermal resistance

The EU Directives and Estonian legal acts prescribe standards for thermal resistance in newly-built buildings, according to which the heat transfer rate through a building's wall must not exceed 0,2–0,24 W/m^2 ºC. It is necessary to ensure that all planned buildings meet this requirement. Unfortunately, the concrete elements that are currently used in house building do not meet those requirements, and do not mention the other targets set by the other European states, according to which the heat transfer rate through walls must not exceed 0,2 W/m^2 ºC. Special attention must be paid to the construction of dwellings that have minimal energy demands.

4.3.4. Expansion of the use of heat pumps

A heat pump enables the use of 2-4 times less energy. Today, Tallinn has put into operation about 10,000 heat pumps, and their number will increase 1.5 times in the coming three years. Heat supply through a heat pump system particularly suits private houses and small apartment houses. This system enables the saving of about 50MW of energy annually.

4.3.5. Use of solar energy

The expansion of solar energy use is essential for those dwellings having low energy demand - solar panels will become the simplest solution for heat supply to these buildings. It can be applied to both private houses and public facilities. Modern technical solutions and conditions allow the use of solar panels in electricity generation as well, though electric power generated in this way is more expensive than that transmitted through the power transmission line.

If currently the share of solar energy in thr power supply is insignificant and remains below 1% in the years to come, then, considering all technical developments in the field of the use of solar energy, the its share should increase greatly in the near future.

4.3.6. Renovation of district heating networks

The renovation implies the replacement of old pipelines having poor thermal insulation with pre-insulated pipes. The district heating pipelines which belong to AS Tallinna Küte are 420-kilometres long, of which only 106 km (25%) have pre-insulated pipes. Each year, 2-3 kilometres of heating pipeline networks are replaced with new ones. In addition, new pipelines are being built. The average age of the district heating network is more than 23 years. In the following years, the scope of pipeline reconstruction is to be expanded. In order to maintain an appropriate technical state of the heating network and decrease heating losses, at least 10-12 kilometres of pipelines are to be renovated annually, which is 3-4 times more than the current average volume of work. Investment in the renovation of heating networks comprises about 120-140million kroons per year. Nowadays heat supply to buildings as a trend in the Energy Efficiency Action Plan faces the problem of energy over-consumption, so implies the widest range of opportunities for energy saving. This may be proved by the results of the urban heat supply system development that have been achieved over the last decade. It is essential to proceed with the reduction of the energy demand of buildings.

4.4. Technical developments

Technical development requires a lot of investment to be made, and this issue is handled by those enterprises that have set a goal to develop their energy economy. Since a number of these enterprises are directly related to Tallinn, the city has a vital role in this matter.

4.4.1. Tallinn Power Plant

Tallinn (Väo) Power Plant, which belongs to AS Tallinna Küte, started producing at the end of 2008, and is currently titled Tallinn Power Plant Ltd. Being an environmentally friendly enterprise, the Plant uses local fuel, i.e., woodchips and peat. The Plant produces 8-10% of the electric power consumed in Tallinn, as well as a quarter of thre heat supplied to the city's district heating networks. The establishment of the Plant has contributed to the reduction in the use of fossil fuel within the process of energy supply to Tallinn.

4.4.2. Organisation of waste management and establishment of waste-to-energy plant

In Tallinn it is necessary to sort and recycle the waste generated. Works in this direction are being performed, however, this field requires an integrated solution. For this purpose, it is necessary to organise waste sorting, further use of recycled waste, biowaste composting, and organic waste incineration. Nowadays the Iru Power Plant, which belongs to Eesti Energia AS, is planning to build waste-to-energy plant.

4.4.3. The maximum use of biogas in the Sewage treatment plant

Biogas released upon solid waste digestion is being used in sewage treatment plant both in the gas engine and as a boiler fuel. A quarter of the biogas is burnt in an open flame in so-called candles. It is planned to use all the biogas for energy generation, requiring the installation of a new gas engine that would allow the production of both electric power and heat.

4.4.4. Renovation of boiler-houses and construction of local power and heating plants

Several boiler-houses have to be modernised in order to increase their power efficiency and enhance fuel consumption procedure. This includes both the replacement of old boilers and renovation of the existing ones. Boiler-houses that belong to AS Tallinna Küte, Tallinn's largest heat supplier, have a good technical state and high power efficiency, while small-scale boiler-houses require modernisation and improvement of their power efficiency rate.

It is also essential to find ways to transfer the heat which has been generated through the cogeneration system to Tallinn's district heating networks. It is necessary to support the construction of power and heating plant which would substitute for the existing small-scale boiler-houses and transfer the produced heat to Tallinn's central heating network. This will contribute to the development of an efficient cogeneration method which is widely used in Europe.

4.4.5. Establishment of biofuel filling stations

Nowadays, Estonia generates more biofuel that is necessary to meet the requirement according to which the share of biofuel shall comprise 10% of all transport fuel. Biofuel has less negative impact on the environment, and it is necessary to establish appropriate facilities at the filling stations. Such facilities have been introduced and operated at AS Statoil petrol station for some time. It is vital to make joint efforts to run biofuel filling stations.

4.4.6. Public transport development and construction of the tram line in Lasnamäe district

The Tallinn Transport Department aims to develop urban transport. For this purpose, public transport routes will be optimised and new lines put into operation, as required. The use of biofuel in the most intensive public-transportation lines would significantly reduce the air pollution level in the city.

The construction of the tram line in the Lasnamäe district is an important trend. Currently, a common interest agreement has been concluded with Chinese investors for the construction of the tram line in the Lasnamäe district between 2011 and 2015 at a total cost of 3.8 billion kroons. This solution will contribute to the reduction in the consumption of diesel fuel oil in thre public transport sector and the improvement of the general urban atmosphere.

4.5. Conclusion

Energy saving requires the implementation of all the abovementioned measures within the next three years. As the result, we will be able to achieve the intended reduction of environmental pollution and enhance energy saving by 2020.

5. Volume of expenditures and investments, and financial resources

Expenditures related to the fulfilment of the set target are very high, i.e., in the range of billions of kroons. The accomplishment of the set tasks requires the involvement of the city's budgetary means, state funds, the co-operation of private investors, and European Union support programmes.

5.1. The role of the city

Within the framework of energy saving measures, the city is to organise, launch comprehensive investigations, prepare and execute organisational measures, and keep control of the whole implementation process. The city will spend 20 million kroons on the execution of energy saving organisational measures. The payback period of the investments in both promotional activities and energy efficiency measures will take a number of years.

The second important and the most energy-efficient financial trend of the city in this respect is renovation of the city-owned buildings for the sake of energy saving, and the support of energy audits for dwellings in the private sector (housing associations), as well as the issuing of the corresponding energy performance certificates. As to the renovation of schools and kindergartens special attention is to be paid to the insulation of buildings and thre improvement of their internal conditions. The construction of new buildings shall meet all revelent modern requirements.

Further development of Tallinn's outdoor lighting is an important trend. The technical performance and the development of Tallinn's outdoor lighting are controlled by the electrical engineering company KH Energia-Konsult Ltd, however, the development trends of outdoor lighting are prescribed by Tallinn Municipal Services Department, which also pays for the electricity consumed in outdoor lighting, or 40 million kroons per year. It is necessary to spend at least 20% of the this amount annually on the further development of outdoor lighting systems which would enable the reduction of the amount of electricity consumed by the city's illumination systems.

Public transport development will also contribute to the direct urban organisation. The city maintains the development and financing of several trends, which are as follows:

- the establishment of optimum public transport layout;
- the use of biofuel in the public transport sector;
- the construction of the tram line in the Lasnamäe district;
- the use of fuel-efficient official cars.

The construction of the tram line in thre Lasnamäe district is definitely the most expensive project of all, the projected cost of which amounts to 3.8 billion kroons. The construction of the tram line aims not only to achieve a considerable energy saving but also enhance eastward traffic in Tallinn.

The city plays a more significant role in the promotion of an energy saving lifestyle, as well as in the fulfilment of organisational measures, than just in the financing of the whole energy saving project.

Table 16. Financed energy-saving activities in Tallinn

	Activity	Energy saving per year (GWh)	Period	CO_2 reduction (t)	Costs (mln kroons)	Notes
1 .	Organisation of energy efficient days	Contributes to changing of consumption habits	2010–2020		5–8	
2.	Energy audit and energy passport issuing for city-owned buildings	Contributes to heat-insulation in buildings	2010–2020		8–10	
3.	Renovation and heat-insulation of city-owned buildings	50–100	2010–2020	14350–28700	500–800	
4.	Further improvement of outdoor lighting control systems	2–3	2010–2020	2500–3750	25–30	
5.	Use of energy-saving lamps in outdoor lighting	4–5	2010–2020	5000–6000	150–200	
6.	Use of energy-saving lamps in the city's organisations	5–10	2010–2015	6300–12600	3–5	

7.	Changing of energy consumption habits in the city's organisations	4–5	2010–2020	5000–6000	1–2	
8.	Use of biofuel in the urban transport sector	10–20	2010–2020	2500–5000	10–20	
9.	Use of fuel-efficient official cars	2–3	2010–2020	600–1000		
10.	Construction of the tram line in Lasnamäe district	5–10	2010–2020	1500–3000	3500–4000	
	Total	**82–156**		**37750–66000**	**4200–5050**	

5.2. The role of the private sector and enterprises

Heating supply expenses will be incurred by the buildings' owners, but the financial support lent by the city is also essential. Today, the city subsidy for the issuing of an energy performance certificate amounts to 1,500 kroons, and KredEx company lends support to the execution of energy audist and the drawing-up of plans for renovation projects, as well as providing low-interest loans for the execution of renovation works. All these factors form favourable terms for the renovation of buildings and enhancing an energy-saving environment.

Expenses for the implementation of new technical solutions, such as heat pumps and solar energy are mainly incurred by the owner of a system or a building, i.e., a house owner (in case of a housing association) or the owner of an enterprise.

Elering OÜ and Eesti Energia Jaotusvõrk OÜ handle the major part of the development of electricity supply to the city. Elering OÜ and Eesti Energia Jaotusvõrk OÜ finance this activity from their budget on account of the saved electric power. Today, it is planned to allocate 100-200 million kroons annually for the renovation of electric power supply systems in the Tallinn area. Much depends on new consumers, i.e., new consumers are to finance their housing associations from their own budgetary means.

Investment in large-scale technical developments, such as the construction of new power and heating plants, waste-to-energy plants and the renovation of district heating networks amounts to billions of kroons, and will be borne by those enterprises that are connected with the corresponding field. The city of Tallinn also has a significant share in this respect. The City Council members could advise AS Tallinna Küte and AS Tallinna Vesi of their position in regard to passing the resolutions necessary to fulfill energy saving projects.

Tallinn Environmental Department is in charge of waste management. It is necessary to pass resolutions in regard to waste management development within the Tallinn area and its neighbourhood, i.e., where shall Tallinn transfer the generated waste to in the future. It is necessary to resolve the issue of the use of waste as soon as possible.

The implementation of energy saving measures in the transport sector concern three parties: the first is the fuel supplier, the second is the transport vehicle manufacturer, and the third is the user of both the supplied fuel and the produced vehicle. Energy can be saved subject to the co-operation of all three parties.

5.3. Other means

In addition to the budgetary means of the city and investors, energy saving measures are also carried out with the aid of financial support funds. For instance, the European Regional Development Fund (ERDF) aims to redress regional imbalances and recessions of the European Union Member States.

One of the measures proposed by the European Regional Development Fund is titled "The wider use of renewable sources of energy to generate energy,"[47] and aims to support projects on renewable energy use. Besides, the whole activity is supported by several European Union structural funds, such as "Improvement of Environmental Infrastructure."

It is possible to apply to EAS for a grant for the implementation of energy saving measures, especially if it is aimed at the development of an enterprise and the utilisation of new technologies.

6. Results and control of the fulfilment of the Action Plan

The Action Plan for Energy Efficiency cannot be a formal document which is followed by everyone without any further responsibilities. On the basis of the present Action Plan, Tallinn Environmental Department is to work out the implementation plan for the fulfilment of specific tasks and indicate the corresponding performers. It is necessary to appoint the relevant structures and officers of the city economy who will be in charge of and take control of the execution of energy efficiency development programs in specific areas. Deadlines shall also be set for performers to submit reports on the results achieved.

6.1. Energy consumption

The fulfilment of the Action Plan for Energy Efficiency aims to increase the energy efficiency rate by 20% by the use of current technologies and enhancing saving consumption habits. It is also necessary to expand the use of environmentally-friendly energy sources. As a result, the share of renewable energy sources in the energy mix is to comprise 20%, and CO_2 emissions are to be reduced by 20% by 2020.

The Energy efficiency rate is to improve by 20%. This can be achieved by the implementation of the following vital measures which have also been mentioned above:

1. the renovation of buildings and decrease in their demand for heating supply to buildings by 23%;
2. the implementation of energy saving electric appliances and lamps in both house-hold and outdoor lighting systems;
3. the renovation of power and district heating networks to reduce network losses;
4. the implementation of energy efficient technologies and new control and regulation systems;
5. raising energy efficiency awareness and the enhancement of energy saving consumption habits.

Tallinn's energy production and consumption is experiencing significant structural changes, as indicated in the third part of the present report. The most noticeable changes are the following:

1. the introduction of Tallinn (Väo) Power Plant, which generates electric power and heat from renewable fuel;
2. the incineration of waste in waste-to-energy plant to generate electricity and heat that is further used in Tallinn;
3. the share of biofuel in the transport sector is to amount to 10%;
4. wider use of new energy sources, such as heat pumps and solar energy.

Tallinn has increased the share of renewable fuel in heat and power generation process, so reducing the volume of purchased energy. In addition, energy is going to be produced in new energy enterprises such as Tallinn Power Plant and waste-to-energy plant. All these factors contribute to the changes in Tallinn's energy consumption structure (see table 17 "Energy consumption (GWh);" and Annexes 1 and 2).

Table 17. Energy consumption (GWh)

	2007		**2020**		**Difference**	
	GWh	%	GWh	%	GWh	%
Fuel consumption	7118	70,5	7509	78,4	391	5,5
incl. renewable fuel	582	8,2	2704	36,0	2122	364
incl. fossil fuel	6535	91,8	4804	64,0	–1731	–26,5
Purchased heat	986	9,8	400	4,2	–586	–59,5

Purchased electricity	1994	19,7	1670	17,4	–324	–16,2
Total	**10098**		**9579**		**–519**	**–5,1**

In Tallinn 2020, general energy consumption is going to reduce by 519GWh or 5.1% as compared to the year 2007. The share of purchased heat and electric power will also reduce, as Tallinn is to produce 16% of the required amount of electricity in its own power plant.

In Tallinn 2020, general fuel consumption is to increase by 391GWh or 5.5% as compared to the year 2007, which is related to the potential establishment of new power plant and waste-to-energy plant based on renewable fuel. At the same time, the use of fossil fuel is to decrease by 12.7%.

It is very important that the use of renewable fuel is going to be increase 3 1/2 times. If in 2007 the share of renewable energy comprised only 8,2%, then in 2020 it will amount to more than 36% of total fuel consumption.

6.2. CO_2 emissions reduction

Expansion of the use of renewable energy contributes to the reduction in CO_2 emissions which is released upon the combustion of fuel by 369 thousand tons or 23.9% (see Annex 3). It is essential to reduce CO_2 emissions in the power industry, while its share in the transport sector is to decrease by 10%.

Due to the reduction in indirect CO_2 emissions which result from purchased electric power and heat, its total amount will decrease by 49.7%, which is twice as much. In this respect it is important to expand the use of renewable energy in the production of electric power over all Estonia. In 2020, there will be no more old pulverised firing boilers in Narva Power Plant blocks. In Narva, Electricity will be produced in new fluidised bed technology energy blocks, by wind turbine generator systems, and in balancing and peak load power plants.

Indirect CO_2 emissions can be dramatically reduced by the expansion of renewable energy use in the production of electricity in Estonia.

6.3. Control over the fulfilment of the Action Plan

According to the structure of the city government, the fulfilment of energy efficiency tasks has been divided between the city government, the district governments, and six departments, i.e., the Environmental Department, the Municipal Services Department, the Enterprise Department, the City Planning Department, the City Property Department, and the Transport Department, which makes it difficult to monitor the full execution of energy efficiency development programmes.

In order to organise the energy policy and develop an efficient energy economy in the city of Tallinn, it is necessary to appoint energy departments that would manage corresponding works and monitor whether the obligations undertaken have been performed. If the City Government follows the economy regime strictly, it may put restraints on the formation of new departments. In this case, the city at least needs to appoint a specialist who would co-ordinate activities directly connected with the whole urban energy economy. Such a specialist shall have both a good command of the subject and the authority to monitor the fulfilment of the development programmes.

From time to time, it makes sense to involve unbiased specialists, such as consulting firms, who would assess the works done and set goals for subsequent activities.

In order to keep the fulfilment of the Action Plan under control, it is necessary to establish a committee among the departments to monitor and control the execution of the saving energy economy action plan. A committee shall consist of representatives of all concerned departments, as well as outside specialists. Such a committee shall be accountable to one of the deputy mayors.

7. Risks related to the accomplishment of the set objectives

7.1. Financial risks

Financial risks may result from the changes in political or development priorities within the framework of drawing up a budget for each following year. These risks could be reduced by the regular substantiation of costs and profit arising from the fulfilment of a development programme, a continuous submission of data on energy consumption fluctuation, and the analysis of statistical reports on energy consumption, as well as by the disclosure and explanation of the investigations' results.

From time to time, the Action Plan is to be reviewed in order to estimate the real volume of the work performed `in both natural and monetary value. The financial support of further action plans shall be lent to those measures that have been recognised as the most energy efficient ones.

7.2. Administrative risks

Administrative risks may result from a failure to reach full co-operation between the network of the action plan performers, its administrative management (the City Government officers, the Departments), and management bodies (i.e., actual work performers, such as urban facilities, private enterprises, population), where, in other words, the co-operation between the responsible parties is insufficient or there is no co-operation at all. Administrative risks may also include changes in the City Government structure and in the number of specialists responsible for a particular field.

Such risks could be reduced by the institution of a inter-local coalition of the City Government which would consist of the representatives of the City Government and separate departments. This would significantly reduce the impact of both potential changes in the structural management and any replacements of the relevant specialists.

7.3. Political risks

Political risks may result from any political wilful changes in the City Council and the City Government, or from a deterioration in the confidence of society in the state which may put restraints on the development of democracy. Political wilful changes may arise from amendments in the priorities of the City Government or the Council, changes in the City Government structure, or any re-organisations in the political parties. A slowdown in the development of democracy may arise from a shift in the priorities of the Government of the Estonian Republic, which may lead to the growth of social inequality in all spheres.

In order to reduce these risks those carrying out development programmes shall keep politicians regularly informed about the current process of works, and maintain the attention and interest of the public in the whole programme. In case there are any changes in political leadership, those carrying out development programmes shall inform the new leaders about the whole subject, the current work process, and about all corresponding difficulties they have encountered so far.

7.4. Risks related to the communication means

Risks related to communication means may result from an insufficient and purposeless information flow. Information failure may also arise when a person dealing with data disclosure is poorly informed about the subject or has a lack of the required qualifications.

These risks could be avoided by drawing up a specific communication strategy, and the establishment and maintenance of a permanent feedback system. It is also essential to keep all relevant departments, specialists and society informed about the progress of the action plan.

7.5. Social risks

Social risks may result from any problems in relationships between those carrying out the action plan, i.e., between individuals, groups or organisations. Social risks are further aggravated when team members do not have well-directed guidelines and tasks for the fulfilment of an energy efficiency action plan. The distribution of work tasks must be based on a member's qualifications in a revelant subject.

In order to reduce social risks it makes sense to convene regular meetings, debates, roundtable discussions, and to involve all participants in decision making procedure, listen to their reports and proposals, and consider their opinions. It is important to direct a team towards the achievement of a shared objective, and to implement team work on a regular basis.

7.6. Risks coming from motivation

Risks related to motivation may result from low salary rates of those carrying out an action plan, poor estimation of achieved results or insufficient managerial recognition for work performed. It has to be taken into consideration that those individuals who are responsible for the execution of the specific tasks of a development programme have enough qualifications in the relevant sphere, and are materially motivated.

In order to reduce such risks, participants should be involved in the managerial process, sufficient recognition for work performed from the departments, the City Government, and organisation supervisors ensured, and this system maintained on a regular basis.

7.7. Risks related to the qualification

The fulfilment of the Action Plan may face certain difficulties arising from poorly qualified workers. Those individuals who are responsible for the execution of the specific tasks of a development programme must have a sufficient level of qualification to accomplish the set targets.

In order to reduce such risks, the required employees must be selected on a competitive basis in order to gauge the professional skills of a candidate, and to establish and maintain advanced training system on a regular basis. Employees shall be provided with further vocational training in case some more complicated work is added to their regular duties.

7.8. Economic crisis

There are some risks related to the economic crisis, however they belong to the category titled *force majeure*, and must be resolved with the implementation of emergency measures. At the same time, it is necessary to find some positive aspects of the economic crisis. Indeed, severe economic conditions lead to a budgetary shortfall, but this situation is just the right time in which to save all possible costs. The current financial crisis led to a reduction of prices for construction materials and expenditure; labour power has also become cheaper as compared to previous years.

It is impossible to prevent general economic crisis at the local level, however, it is reasonable to maximise the use of all its ensuing consequences.

8. Recommendations for the achievement of the Action Plan

What can be done to accomplish the set 20-20-20 task, i.e., to increase energy efficiency by 20%, to ensure a 20% share of renewable energy sources in the energy mix, and to reduce CO_2 emissions by 20% by 2020? In addition to the large amount of investment to be made, it is also important to ensure the changing of the consumption habits of residents, as well as the promotion and development of energy-efficient behaviour.

Recommendations for the fulfilment of the development programme of the energy-saving energy economy have been mentioned in the previous chapters. It is essential to ensure the accomplishment of the aimed target, i.e., to increase energy efficiency by 20%, to ensure 20% share of renewable energy sources in the energy mix, and to reduce CO_2 emissions by 20% by 2020. All planned activities and the list of the appointed participants in regard to the fulfilment of the present Action Plan are indicated in Annex 6.

The accomplishment of the set tasks is feasible. Amid the current financial crisis, which requires the implementation of energy saving measures in each and every sphere, we have to start with small-scale tasks.

It is very important to establish the appropriate energy-efficient behaviour of the consumers, i.e., of individual consumers, housing associations and enterprises, as well as of the whole city. Each consumer can save up to 10-20% of electricity by undertaking energy-saving and rational activities. The renovation of apartment houses will ensure sufficient heat-insulation and reduce costs for those buildings heating by up to 30%. All these opportunities are to be introduced to consumers through the organisation of energy efficient days and advertising campaigns.

The second important guideline involves the disclosure of information of those enterprises dealing with urban energy supply issues; it is also essential to provide these enterprises with the support needed. Thus, Eesti Energia AS cannot operate the urban electric power supply without the co-operation due of consumers, i.e., residents and enterprises. The City Government is to provide due guidance in the deliberate and energy-saving improvement of the district heating network.

It is important to use all available energy sources. This is perfectly exemplified by the construction and commissioning of the Tallinn (Väo) Power Plant based on renewable fuel. The plant produces 20-25% of the heat transmitted to Tallinn's district heating networks and 8-10% of the electricity consumed in the city.

The implementation of all these small and large-scale measures allows Tallinn to fulfil the set 20-20-20 obligation by 2020.

9. Conclusions and proposals

1. Tallinn has joined the Covenant of Mayors and undertook the liability to reduce its CO_2 emissions by 20%, as a result of 20% increase in energy efficiency and a 20% share of renewable energy sources in the energy mix by 2020.
2. The preparation of the present Action Plan has been based on international regulatory documents, and on the legal acts of the Republic of Estonia and the city of Tallinn which handle the production, consumption, and saving of energy.
3. The Action Plan provides a detailed analysis of energy production and consumption in Tallinn both by various industries and the city's inhabitants.
4. The Action Plan provides a range of opportunities for the accomplishment of the set energy-saving task, i.e., how to enhance energy-efficient consumption, increase the share of renewable fuel in energy supply process, and reduce the amount of CO_2 emissions into the atmosphere.
5. It is important to change the urban energy consumption structure. It is necessary to involve new cogeneration technologies, the use of renewable fuel, and waste and waste residual heat in the energy economy processes, especially in energy supply to the city.
6. To ensure a continuous improvement of the urban district heating and its networks as environmentally friendly modes of production.
7. The most significant energy-saving opportunity consists in the reduction of the demand for heating buildings. The insulation of buildings will enable the reduction of costs for their heating by up to 30%.

8. As for the transport sector, special attention must be paid to the development of the urban transport systems, and an increase in the share of biofuel by at least 10% in both public and private transport.
9. It is important to raise awareness of all residents in regard to energy-efficient opportunities through the organisation of energy efficient days and advertising campaigns.
10. All entrepreneurs must be informed about the set energy-saving tasks, and it is necessary to ensure that each and every entrepreneur works diligently at the implementation of energy-efficient measures in every enterprise.
11. The City Government and the city Departments have an essential role in the organisation of energy saving measures and the supervision of works performance.
12. The implementation of all organisational and technical opportunities, as well as the co-operation between the City Government, private enterprises, and other units will allow the accomplishment of the set energy-saving task by 2020, reduce the level of air pollution, as well as reach and even exceed the set 20-20-20 target.

10. List of references

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11. Annexes

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3. ANNEX 3. Fuel and energy consumption in Tallinn 2007 and outlook for 2020.
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6. ANNEX 6. Tallinn's Action Plan for Energy Efficiency 2010–2020

ANNEX 1. Fuel and energy consumption in Tallinn 2007

Fuel	Unit	Energy generation	Industry and construction	Business and service	Household	Transport	Total demand	Heating value	Energy (GWh)	Consumption share (%)
Coal	th t			1	7		8	7,5	60	0,6
Peat	th t						0	2,5	0	0,0
Peat briquette	th t				4		4	4,4	18	0,2
Wood fuel	th solid cubic meter		2	10	130		142	2,1	298	3,0
Wood chip and pellet	th solid cubic meter	50	6		100		156	1,7	268	2,7
Natural gas	mln m³	165	34	31	28		258	9,3	2407	23,8
Liquid gas	th t		1		2		3	12,7	38	0,4
Biogas	mln m³			3			3	5,3	16	0,2
Shale oil	th t	1	1	1			3	10,9	33	0,3
Light fuel oil	th t	2	6	1	4	20	33	11,8	389	3,9
Diesel fuel oil	th t		13	6	16	139	174	11,8	2053	20,3
Petrol	th t				77	49	126	12,2	1537	15,2
Biofuel in transport sector	th t						0	10,3	0	0,0
Waste	th t						0	2,9	0	0,0
Purchased electricity	GWh	24	753	726	466	25	1994		1994	19,7
Purchased heat	GWh		89	167	730		986		986	9,8
Total energy	GWh	**1684**	**1422**	**1320**	**3173**	**2499**	**10098**		**10098**	100,0
Total purchased energy	GWh	24	842	893	1196	25	2980		2980	29,5
Total renewable fuels	GWh	86	15	37	445		582		582	8,2
Total fossil fuels	GWh	1574	565	390	1532	2474	6535		6535	91,8
Total fuels	GWh	1660	580	427	1977	2474	7118		7118	70,5

ANNEX 2. Outlook for fuel and energy consumption in Tallinn 2020.

Fuel	Unit	Energy generation	Industry and constructi on	Business and service	Household	Transport	Total demand	Heating value	Energy (GWh)	Consumption share (%)
Coal	th t		1	1	1		3	7,5	23	0,2
Peat	th t	30					30	2,5	75	0,8
Peat briquette	th t				2		2	4,4	9	0,1
Wood fuel	th solid cubic meter		2	10	90		102	2,1	214	2,2
Wood chip and pellet	th solid cubic meter	850	6		40		896	1,7	1523	15,9
Natural gas	mln m³	50	26	24	20		120	9,3	1120	11,7
Liquid gas	th t		1		2		3	12,7	38	0,4
Biogas	mln m³	3		2			5	5,3	27	0,3
Shale oil	th t	1	1	1			3	10,9	33	0,3
Light fuel oil	th t	1	1	1	2	18	23	11,8	271	2,8
Diesel fuel oil	th t		11	5		141	157	11,8	1853	19,3
Petrol	th t					113	113	12,2	1383	14,4
Biofuel in transport sector	th t					35	35	10,3	361	3,8
Waste	th t	200					200	2,9	580	6,1
Purchased electricity	GWh	16	635	619	384	16	1670		1670	17,4
Purchased heat	GWh		36	68	296		400		400	4,2
Total energy	GWh	**2621**	**1101**	**1032**	**1189**	**3636**	**9579**		**9579**	100,0
Total purchased energy	GWh	16	671	687	680	16	2070		2070	21,6
Total renewable fuels	GWh	2041	14	32	257	361	2704		2704	36,0
Total fossil fuels	GWh	564	415	313	252	3260	4804		4804	64,0
Total fuels	GWh	2605	430	345	509	3620	7509		7509	78,3

ANNEX 3. Fuel and energy consumption in Tallinn 2007 and outlook for 2020.

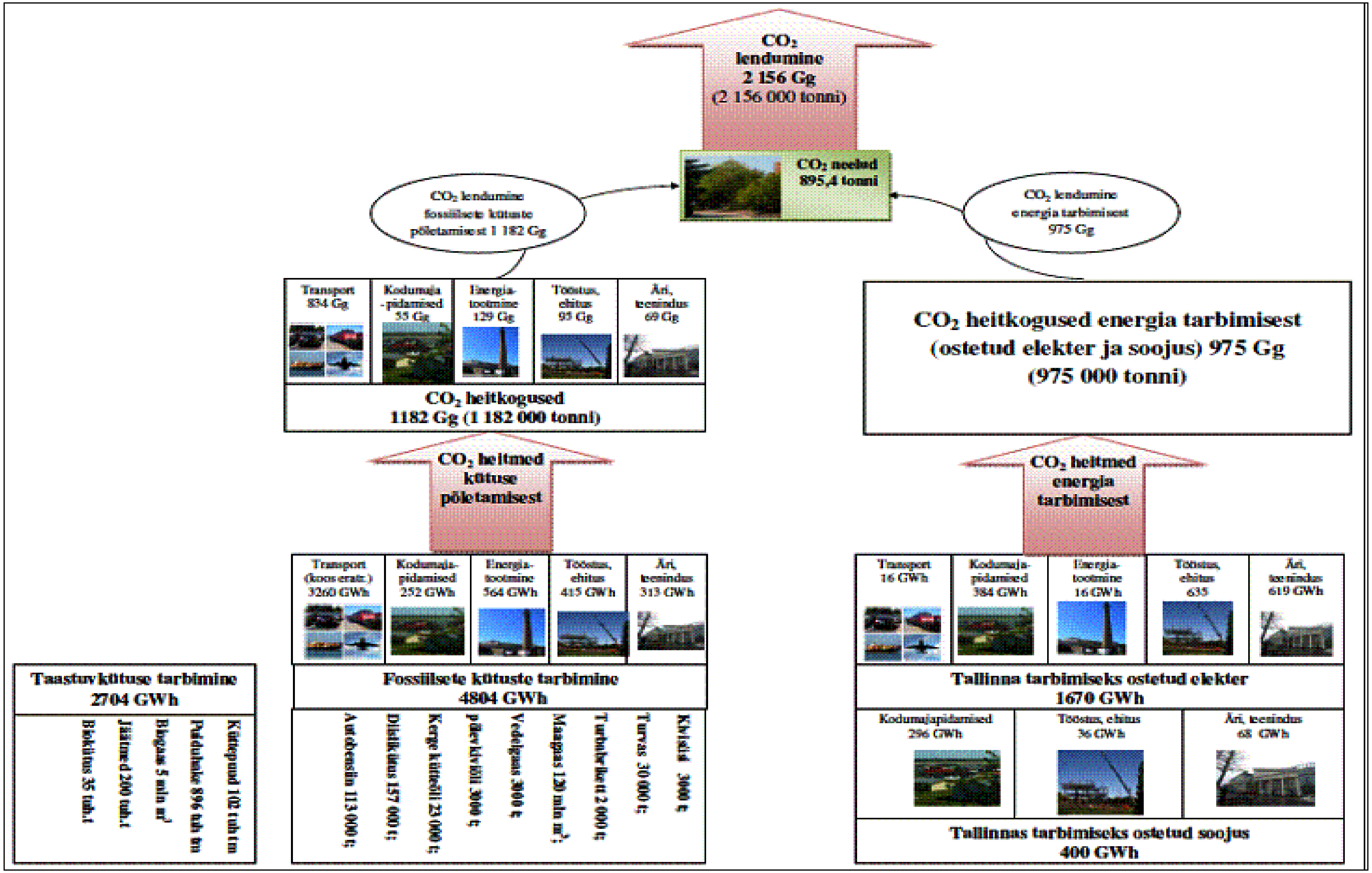
Fuel	Unit	2007			2020			Difference		
		Total demand	Energy (GWh)	Consumption share (%)	Total demand	Energy (GWh)	Consumption share (%)	th t th solid mln m³	Energy (GWh)	Change (%)
Coal	th t	8	60	0,6	3	23	0,2	–5	–38	–62,5
Peat	th t	0	0	0,0	30	75	0,8	30	75	
Peat briquette	th t	4	18	0,2	2	9	0,1	–2	–9	–50,0
Wood fuel	th solid cubic meter	142	298	3,0	102	214	2,2	–40	–84	–28,2
Wood chip and pellet	th solid cubic meter	156	268	2,7	896	1523	15,9	740	1255	467,7
Natural gas	mln m³	258	2407	23,8	120	1120	11,7	–138	–1288	–53,5
Liquid gas	th t	3	38	0,4	3	38	0,4	0	0	0,0
Biogas	mln m³	3	16	0,2	5	27	0,3	2	11	66,7
Shale oil	th t	3	33	0,3	3	33	0,3	0	0	0,0
Light fuel oil	th t	33	389	3,9	23	271	2,8	–10	–118	–30,3
Diesel fuel oil	th t	174	2053	20,3	157	1853	19,3	–17	–201	–9,8
Petrol	th t	126	1537	15,2	113	1383	14	–13	–154	–10,0
Biofuel in transport sector	th t	0	0	0,0	35	361	3,8	35	361	
Waste	th t	0	0	0,0	200	580	6,1	200	580	
Purchased electricity	GWh	1994	1994	19,7	1670	1670	17,4	–324	–324	–16,2
Purchased heat	GWh	986	986	9,8	400	400	4,2	–586	–586	–59,4
Total energy	GWh	**10098**	**10098**	100,0	9579	9579	100,0	–519	–519	–5,1
Total purchased energy	GWh	2980	2980	29,5	2070	2070	21,6	–910	–910	–30,5
Total renewable fuels	GWh	582	582	8,2	2704	2704	36,0	2122	2122	364,3
Total fossil fuels	GWh	6535	6535	91,8	4804	4804	64,0	–1731	–1731	–26,5
Total fuels	GWh	7118	7118	70,5	7509	7509	78,3	391	391	5,5

ANNEX 4. CO_2 emissions in Tallinn 2007 and outlook for 2020

Kütus	Unit	Energy generation	Industry and construction	Business and service	H ousehold	Transport	Total CO_2 in 2020	Total CO_2 in 2007	Difference (Gg)	Difference (%)
Coal	Gg		2,6	2,6	2,6		7,8	21,6	–13,8	–63,9
Peat	Gg	28,8					28,8		28,8	
Peat briquette	Gg				3,4		3,4	6,8	–3,4	–50,0
Wood fuel	Gg		1,6	8,1	73,1		82,8	115,3	–32,5	–28,2
Wood chip and pellet	Gg	565,5	4,0		26,6		596,1	103,8	492,3	474,4
Natural gas	Gg	93,8	48,8	45,0	37,5		225,1	484,4	–259,3	–53,5
Liquid gas	Gg		2,8		5,7		8,5	8,5	0	0,0
Biogas	Gg	3,2		2,2			5,4	3,2	2,16	66,7
Shale oil	Gg	3,0	3,0	3,0			9,0	9,0	0	0,0
Light fuel oil	Gg	3,1	3,1	3,1	6,2	56,1	71,6	102,3	–30,7	–30,0
Diesel fuel oil	Gg		34,1	15,5		437	486,5	539,2	–52,7	–9,8
Petrol	Gg					341,1	341,1	380,4	–39,3	–10,3
Biofuel in transport sector	Gg					94,0	94,0		94,0	
Waste	Gg	235,2					235,2		235,2	
Purchased electricity	Gg	8,5	336,5	328,1	203,5	8,5	885,1	2512,4	–1627,3	–64,8
Purchased heat	Gg		8,1	15,3	66,6		90,0	222,0	–132	–59,5
Total purchased energy	Gg	8,5	344,6	343,4	270,1	8,5	975,1	2734,4	–1759,3	–64,3
Total renewable fuels*	Gg	803,9	5,6	10,3	99,7	94,0	1013,5	222,3	791,2	355,9
Total fossil fuels	Gg	128,7	94,4	69,2	55,4	834,1	1181,8	1552,2	–370,4	–23,9
Total purchased energy and fossil fuels	Gg	137,2	439,0	412,6	325,5	842,6	2156,9	4286,6	–2129,7	–49,7

*Total amount of CO_2 emissions from renewable fuel has not been assessed.

ANNEX 5. Tallinn CO2 balance scheme for 2020.



ANNEX 6. Tallinn's Action Plan for Energy Efficiency 2010–2020

	Activity	Annual production output (GWh)	Period	Performer	CO_2 reduction [t]	Notes
1.	Commissioning of Tallinn Power Plant based on using wood chips for fuel	Energy produced from wood chips will substitute for heat generated from gas fuel	2009	OÜ Digismart	492000	
2.	Construction of waste-to-energy plant for waste incineration in Tallinn	Up to 310GWh Substitution of heat generated from gas fuel		Eesti Energia AS Iru Power Plant?	235000?	The Iru Power Plant is located in Maardu; it uses waste generated in Tallinn as the main fuel, and transfers heat to Tallinn's district heating networks
3.	Use of waste water residual heat in Tallinn Paljassaare Sewage treatment plant	100–120	2012–2015	AS Tallinna Vesi AS Tallinna Küte AS Tallinna Soojus	28700–43000	
3.	The maximum use of biogas from Paljassaare Sewage treatment plant	2–3	2010–2012	AS Tallinna Vesi	2540–3800	
4.	Construction of power and heating plant based on landfill biogas in Tallinn landfill	15–25	2010–2012	Tallinna Prügila AS		Tallinn Landfill is located in Jõelähtme parish, but deposits waste generated in Tallinn
5.	Construction of waste fuel production line in Tallinn landfill	40–60 th tons	2010–2012	Tallinna Prügila AS		Tallinn Landfill is located in Jõelähtme parish, but deposits waste generated in Tallinn
6.	Construction of waste fuel production line in Lasnamäe district	40–60 th tons	2012–2015	Waste treatment organizations		CO_2 reduction is achieved by waste fuel use

7.	Construction of gas turbine power plant to supply heat to Tallinn's district heating networks	Heat generated by cogeneration process will substitute heat generated in Tallinn gas boiler houses	2015–2018	Private enterprises AS Tallinna Küte		Wind turbine generation systems
8.	Construction of local power and heating plants next to local boiler houses and heating networks	Heat and electricity cogeneration system	2012–2020	Eesti Energia AS Fortum Termest AS		
9.	Renovation of district heating network to reduce heating losses	20–40	2010–2020	AS Tallinna Küte Fortum Termest AS	5000–10000	
10.	Connection of the heating networks between Eastern and Western districts in Tallinn	Contributes to the efficient performance of heat producers	2012–2015	AS Tallinna Küte		
11.	Energy audits, thermographic investigations, and energy performance certificates	Contributes to buildings heat-insulation	2010–2020	Buildings' owners		
12.	Buildings renovation and heat-insulation	200–300	2010–2020	Buildings' owners	57400–86100	
13.	Construction of buildings of high thermal resistance	50–100	2010–2020	House builders	14350–28700	
14.	Wider use of heat pumps in heat supply to buildings	60–100	2010–2020	House builders and owners	8600–14300	
15.	Use of solar energy in			Buildings' owners		

	hot water and electricity supply	2–5	2010–2020		2500–6300	
16.	Use of energy-efficient technologies in production process	50–100	2010–2020	Enterprises and manufacturers	38700–77400	
17.	Gas emissions reduction upon electricity generation in Estonia and reduction of Tallinn's indirect gas emissions		2010–2020	Eesti Energia AS and other electricity producers	1627000	With due account for structural changes in electricity production in compliance with the Development Plan of the Electricity Sector
18.	Renovation of Elering OÜ tie-stations and power lines	20–30	2010–2020	Elering OÜ	10600–16000	
19.	Renovation of distribution networks and medium voltage substations	30–50	2010–2050	Eesti Energia Jaotusvõrk OÜ and customers	16000–26500	
20.	Use of energy-saving lamps in outdoor lighting	4–5	2010–2020	Tallinn Municipal Services Department	5000–6000	
21.	Further development of outdoor lighting control systems	2–3	2010–2050	Tallinn Municipal Services Department	2500–3750	
22.	Use of energy-saving lamps in house holding and enterprises	50–100	2010–2015	Consumer	63000–126000	
23.	Use of fuel-efficient cars	200–300	2010–2015	Motorcar companies and owner-drivers	53000–80000	
24	Use of biofuel as the	340	2010–2020	Petrol stations and	90000	

	main transport fuel			owner-drivers		
25.	Use of biofuel in urban transport	10–20	2010–2020	The city's public transportation enterprises	2500–5000	
26.	Development of the tram line in Lasnamäe district	5–10	2010–2015	Tallinn Transport Department	1500–3000	
27.	Use of electric home appliances and devices of low energy demand	50–100	2010–2015	Consumers	63000–126000	
28.	Formation of energy-efficient consumption habits	50–100	2010–2020	Consumers	40000–80000	
29.	Organisation of energy efficient days	Contributes to changing of consumption habits	2010–2020	Tallinn City Government		
30.	Training for energy consumers in regard to the implementation of energy-saving manufacturing	Contributes to the implementation of energy-saving technologies	2010–2020	Tallinn City Government, several departments		
	Total	**1920–2500 GWh**			**2840–3220 th t**	

Notes

1. The intended measures ensure energy savings of 19–24.5%, securing the 20% increase in energy efficiency as stipulated by the Covenant of Mayors. Part of the saved energy is further used in the development of industry and the city economy.
2. In Tallinn, the implementation of energy saving measures secures the reduction of CO_2 emissions by at least 20%. The reduction of additional indirect CO_2 emissions is achieved by changing the electric power production structure in accordance with the Development Plan of the Estonian

Electricity Sector. The reduction of additional indirect CO_2 emissions into the atmosphere will be achieved as a result of efficient electricity consumption in Tallinn.

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