A vision for Latvia based on INFORSE's Vision2050

Background note, November 19, 2010, INFORSE-Europe.
Where no other source is given, data is derived from the official Latvitjas Statistika website

1. Introduction

This background note gives an overview of the potentials for renewable energy and energy efficiency that is used in the sustainable energy vision developed by International Network for Sustainable Energy (INFORSE) – Europe and Latvian Green Movement and Green Liberty, Latvia. The vision includes growth in most sectors.

Comments are welcome (see last page)

For reference the note starts with a number of official forecasts for Latvia as well as statistical information (chapter 2).
Then the note gives an overview of renewable energy potentials and the potentials used in Vision2050 (chapter 3).
This is followed by a chapter on energy efficiency potentials, including the assumption of realised energy efficiency potentials with the Vision2050 (chapter 4).
The next chapter gives an overview of growth in Latvia, including current trends and the assumptions of growth used in the Vision2050 (chapter 5).
Finally there is a description of fuel shifts, including changes from imports to domestic production, e.g. of electricity, as well as energy storage demands (chapter 6).

Results of the sustainable energy visions and recommendations are included in two other documents, which are available from www.inforse.org/europe.

The current version of this paper will be improved if new and consolidated information becomes available. All comments are welcome.

In this note we do not use economic growth as a direct driver for energy consumption; but growth in energy services, such as area of heated floor space or transport work.

The Latvian Energy efficiency strategy[1] is out of date and does not go in details describing goals on energy efficiency for heating. However, the overall target of the strategy is to increase energy efficiency, to ensure that by year 2010 Latvia's primary energy consumption on unit of GDP is decreased by 25% from year 2004.

[1] MK 2004.gada 19.maija rīkojums Nr.321

2. Description of Latvian Electricity and Heat Supply and Existing Official Plans for Electricity Production

Total installed energy capacity in Latvia in year 2005 was 2184,6 MW (wind – 26,4; small TPP – 76,1; small hydro – 26,6; big TPP – 519,5; big hydro – 1536) and maximum demand was 1400 MW.

The state-owned Latvenergo is the main energy producer in Latvia, generating power at 3 Daugava hydro power plants (HPP) and 2 Riga thermal power plants (TPP), as well as by Aiviekste HPP with the capacity of 0,8 MW and Ainaži wind station (capacity of 1,2 MW). Riga TPP-2 also has 110 MW emergency turbogenerator and Riga HPP in the high water period (spring) has 200 MW of emergency capacities. Latvenergo's share of the regular capacity is 2054 MW.

Technical characteristics of the HPP:

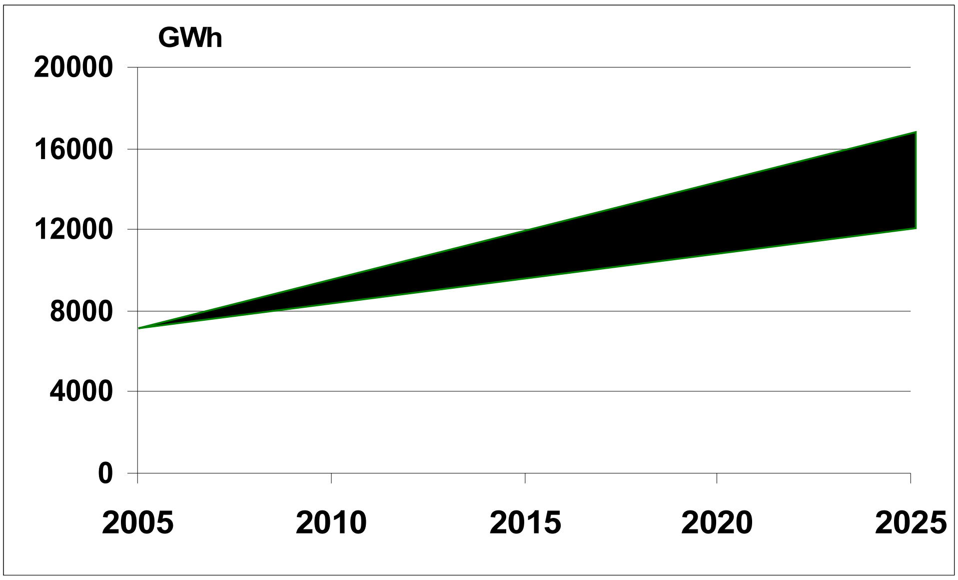
	Ķegums HPP1/HPP2	Pļaviņas HPP	Riga HPP
Installed capacity, MW	72/192	868,5	402
Number of hydro aggregates	4/3	10	6
Maximum head, m	14/14	40	18
Dam length, m	2161	4032	15400
Multiple annual average flow , m^3/s	615	610	640
Water reservoir capacity, million m^3	168,3	500,1	324,6
Estimated minimum energy storage capacity (GWh)[2]	4.9	40	12

Technical characteristics of the Riga TPP:

	Riga TPP-1	Riga TPP-2
Heat capacity (MW)	375	1279
2006/2007 heating seasons average and maximum heat load of the day (MW)	253 / 312	675 / 758
Electric capacity (MW)	142	390
Steam boilers	2	5
Turbo-aggregates	3	4
Water heating boilers	2	4
Fuel	Natural gas (diesel fuel as re-serve fuel for boilers)	Natural gas (heavy fuel oil as reserve fuel)

[2]On the asumption that the average height of the storage is 75% of the head given in the table.

Scenario for electricity demand from Latvia's Investment and Development Agency's study on the base load, 2007:



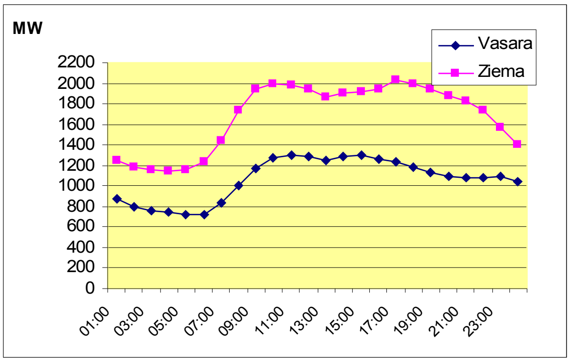
Energy demand scenario developed by Transmission system operator, 26/9 2006:

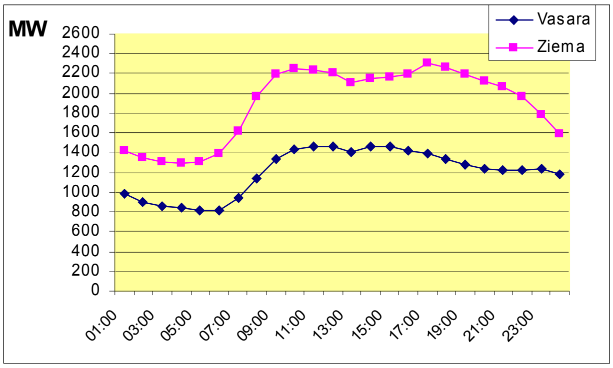
Year	Annual consumption (bruto)	Peak load
	GWh	MW
2005	7051	1272
2006	7482	1420
2007	7689	1474
2008	8068	1531
2009	8463	1589
2010	8610	1650
2011	9031	1715
2012	9342	1782
2013	9794	1852
2014	10264	1925

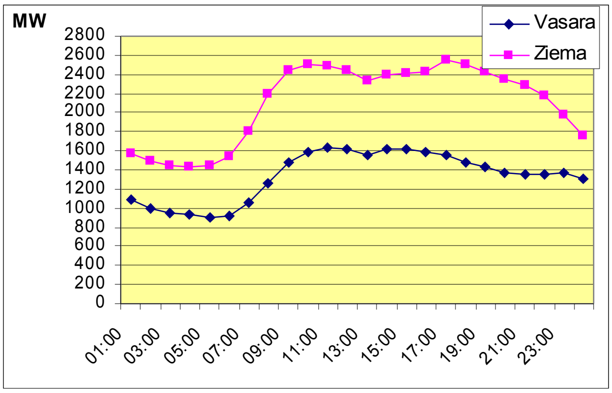
Report from Transmission system operator, scenario for year 2016:

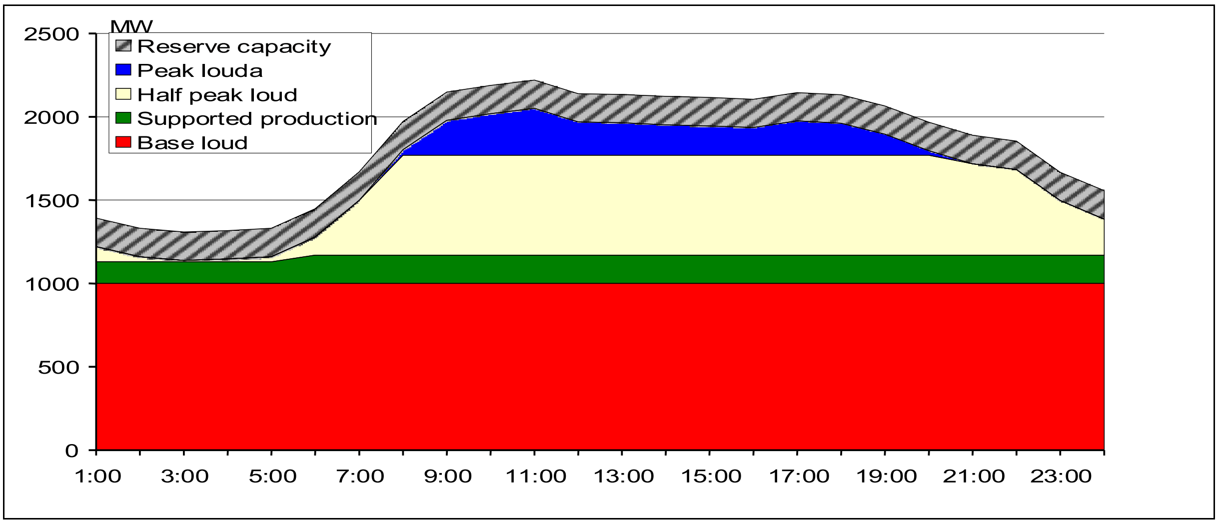
Type	Supported production	Base load	Half peak load	Peak load	Reserve capacity	Imported power
Power, MW	200	1000	600	300	150-250	+- 400
Use, hours a year	>6000	>6000	<3500	<1000	8760	

Max electricity demand (2015, 2020, 2025) (Vasara – summer; Ziema – winter)[3]



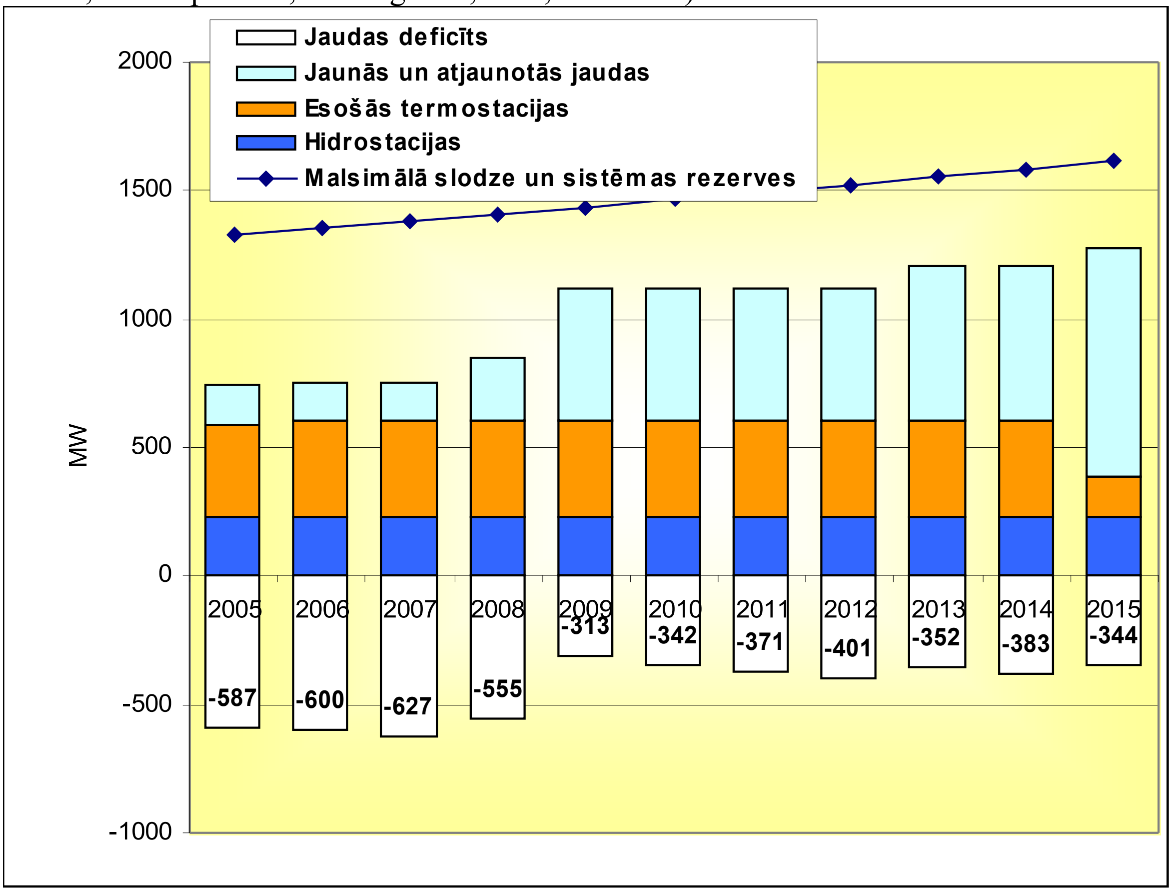






[3] Latvian investment and development agency.

Possible electricity demand in the December when there is a lack of hydro energy. (Legend: deficit, new capacities, existing TPP, HPP, Peak load).



Future plans:

- New combined cycle energy block in Riga TPP 2 by 2008 with capacity 400 MW. After reconstruction it is planned that the energy production in TEC-2 will increase 4-fold - from 0,83 TWh to 3,35 TWh.
- Coal condensation electric station by year 2012 with a capacity of 400 MW in Kurzeme region (Western Latvia at the Baltic Coast).

Development of heat and primary energy demand for heat and processes (PJ, (TWh))[4]

	1995	2000	2001	2002	2003	2004
Final energy consumption, excluding transport sector and electricity		**(26,2)**	**(28,3)**	**(28,7)**	**(29,0)**	**(30,0)**
Centralized heat production	37,9 (10,5)	24,7 (6,9)	26,4 (7,3)	26,3 (7,3)	26,8 (7,5)	24,6 (6,8)
Local heat production *(industry, agriculture and services using primary energy resources)*	40,0 (11,1)	36,6 (10,2)	38,0 (10,6)	40,1 (11,1)	41,0 (11,4)	46,7 (13,0)
Individual heat production *(households using primary energy resources)*	38,0 (10,6)	33,0 (9,2)	37,6 (10,4)	37,0 (10,3)	36,7 (10,2)	36,8 (10,2)

[4] Statement on energy development 2007. – 2016

Information from Energy balance 2005 (TJ):

	1990	1995	2000	2002	2003	2004	2005
Production of heat	99439	46112	31867	33048	33516	31093	31144
of which:							
public CHP	18280	13720	11250	14223	14465	14389	14238
public heat plants	43654	22258	16081	15322	15196	12917	13367
autoproducer CHP	4110	2070	684	515	659	428	439
autoproducer heat plants	31937	8064	3852	2988	3196	3359	3100
utilised heat	1458	-	-	-	-	-	-
Energy sector	**256**	**1800**	**1213**	**871**	**932**	**1195**	**1091**
Losses	**14915**	**6415**	**5947**	**5861**	**5739**	**5317**	**5033**
Final consumption	**84268**	**37897**	**24707**	**26316**	**26845**	**24581**	**25020**
of which:							
industry	**31928**	**1829**	**623**	**572**	**583**	**558**	**634**
other sectors	**52340**	**36068**	**24084**	**25744**	**26262**	**24023**	**24386**
agriculture, forestry, hunting, fishing	8006	360	50	65	87	119	155
construction	1001	140	36	58	43	50	50
households	25891	25175	18411	19508	19933	18119	18360
other consumers	17442	10393	5587	6113	6199	5735	5821

Heat production in Riga by "Rigas siltums":

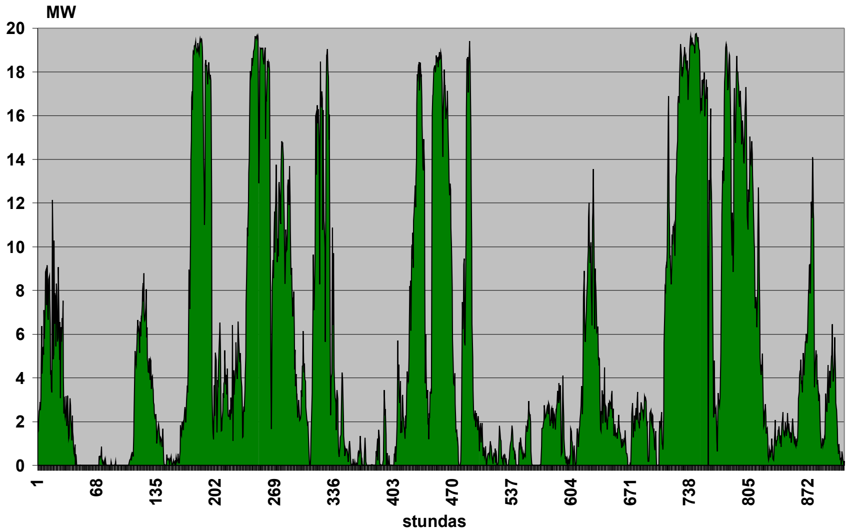
Thermo stations	Riga TPP-1	Riga TPP-2	Vecmil-grāvis	Imanta	Ziepniekkalns	Daugav-grīva
Heat capacity (MW)	375	1279				
2006/2007 heating seasons average and maximum heat load of the day (MW)	253 / 312	675 / 758	40,7 / 45,5	231 / 271	55.9 / 60,9	16,1 / 17,8

3. Renewable Energy Potentials

Windpower
Officially 298 MW of windpower (with a capacity factor of 2300 full-load hours per year), are to be installed by 2010. However, by 2009 only 28 MW had been installed, according to EWEA (see p. 8) and 29 MW according to the Central Statistical Bureau of Latvia.

According to the assessment of Latvias Wind Energy Association, it is possible to install a total of around 600 MW of windpower on land with a power production of 1.3 TWh/year. In addition the association finds that there is an offshore potential of 1200 MW[5].

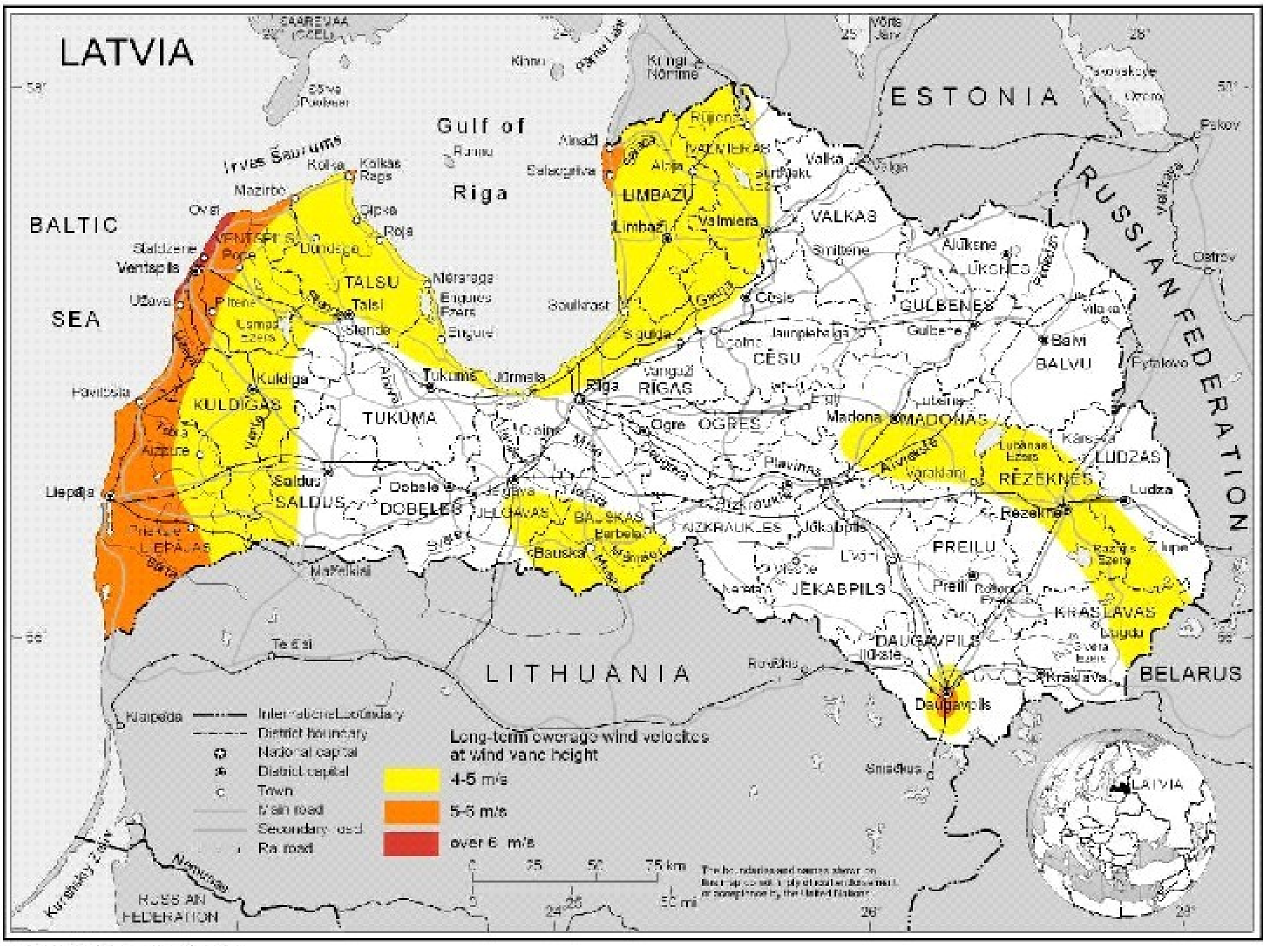
Variation in windpower production as measured in Latvia (stundas = hours), probably 2005.



The best sites for windpower on land are at and behind the Western Baltic Sea coast of Latvia (wind speed in 25m is 6,8-7,0 m/s, but in 50m it is 7,9-8,1 m/s). For environmental reasons, sites should be south of the nature reserves around the Kolka horn. Smaller potentials are in other areas such as sites behind the eastern coast of the Bay of Riga.

The offshore potential is in the Baltic Sea west of Latvia while offshore in the Riga Bay is not considered because of nature protection interests. In addition to this, there is potential for a larger windpower park further into the Baltic Sea.

[5]Included in Atjaunojamo energoresursu potencials Latvija, Agency of buildings, energy & housing, Latvian Ministry of Economy, 2008



MAP NO. 3702 Rev. 1 UNITED NATIONS
JANUARY 1994

Historical windpower production:

	2000	2001	2002	2003	2004	2005
Windpower (GWh)	4,4	3,4	11,2	48,5	49,1	47

It was previously accepted that Latvia has 7 enterprises with 41 wind turbines installed with a combined capacity of 135 MW (2006). However, new data from EWEA suggests the total installed capacity as of 2009 may be as little as 28 MW[6] and this is independently verified by the Central Bureau of Statistics.

For this study a potential of 1800 MW with 2400 equivalent full-load hours is used, which is an average of onshore development with 2000 – 2200 full load hours and offshore with a higher capacity factor. Presently the figure is about 2300 hours.
The potential is divided in 600 MW onshore and 1200 MW offshore.

It was previously expected that 300 MW would be developed by 2010 and the full onshore potential of 600 MW by 2020, but given that only 28 MW in total were installed by the end of 2009, it seems very unlikely that it would increase more than ten-fold in the course of a year. Instead is included 85 MW capacity for 2010 and 300 MW for 2015.
From 2020 offshore development is expected to start and to be fully used in 2030.

[6] http://www.ewea.org/fileadmin/ewea_documents/documents/statistics/100401_General_Stats_2009.pdf, p. 4

Solar Energy
The energy in solar radiation in Latvia is an average 1109 kWh/m^2 on a horizontal surface according to Latvian Renewable Energy Statement 2006, Ministry of Environment. Most of the solar energy will come in the warm part of the year from April when solar intensity is 120 kWh/m^2 for the month on a horizontal surface till first part of September.

Solar energy is not used much in Latvia today. The largest existing solar heating project is installed at the Aizkraukla School[7] with a solar collector area of 208 m^2. There are also a number of smaller projects.

The maximal useful solar collector area is in this study limited to 10 m^2/capita, i.e. 23 mill. m^2.

For this study the area used for solar energy is divided between:

- Solar heating with collectors for hot water (directly used domestically for service sector, industrial heat demand or eventually district heating) with an annual yield of 440 kWh/year (about 40% efficiency) and a potential area of 11 mill. m^2 and
- Solar electric cells (PV-cells) with an annual yield of 110 kWh/year (about 10% efficiency) with a potential area of 11 mill. m^2.

The solar heating installations can be used for low to medium temperature heat demand (below 150'C) and district heating. Normal flat-plate solar collectors will be limited to supply heat below 90'C, while higher temperatures can be achieved with use of vacuum tube solar collectors.

In this study the use of solar energy is limited to the following maximal uses:
- 1/3 of buildings' demand for space and water heating (limited because of seasonal variation) for domestic and service sector heating
- 2/3 of low-temperature process heat (assuming equal demand throughout the year)
- 15% of medium-temperature heat

To cover 1/3 of buildings demand for space heating and hot water will require energy storages of 1-3 months. This is also necessary to cover 2/3 of low-temperature process heat. Because of the costs of such storages, they are only included after 2040. Until then we have limited solar heating installations to cover less than 60% of domestic hot water demand in houses outside district heating, equal to about 15% of domestic total heat demand outside district heating (assuming 25% of total heat demand is used for hot water and 75% for space heating) and 8% of service sector heat demand outside district heating areas. It is also expected that solar heating will cover industrial heat demand, up to 12% in 2050 in some sectors of industry, and 4% of district heating.

There is little market for solar energy installations in Latvia at the moment. This is not expected to change until 2010; but the development of solar heating is then expected to start and then follow a path like:
-2010 – 2020: 10,000 m^2/year (total 110,000 m^2 installed in 2020)
-2021 – 2030: 80,000 m^2/year (total 900,000 m^2 installed in 2030, covering 3% of domestic heat demand)
-after 2030: 200,000 m2/year, covering 9% of service sector heat demand and 12% of household heat demand by 2050. Solar also cover 9% of heat delivered from heat-only stations (CHP excluded)

[7] www.gimnazija.aizkraukle.lv

With this development solar heating will cover about 5 million m^2 equal to 45% of the area of 11 million m^2 discussed above.

The installed area for solar electric generation (PV) is expected to follow a take off similar to solar thermal after 2020; but to expand stronger than solar thermal from after 2030, leading to 53% of the potential area used in 2050.

With this development, 5 million m^2 will be used for solar heating and 5.8 million m^2 will be used for solar electric generation, in total about 11 million m^2. This is equal to 5 m^2/person for solar energy use in 2050 in total. Most of this is expected to be on rooftops. This area is of course not a maximum; it leaves room for additional solar installations after 2050.

Biomass

The potential for solid biomass for energy consists of wood and straw available for energy purposes. Bio-fuel for transportation, biogas and energy plantations are all treated separately below.

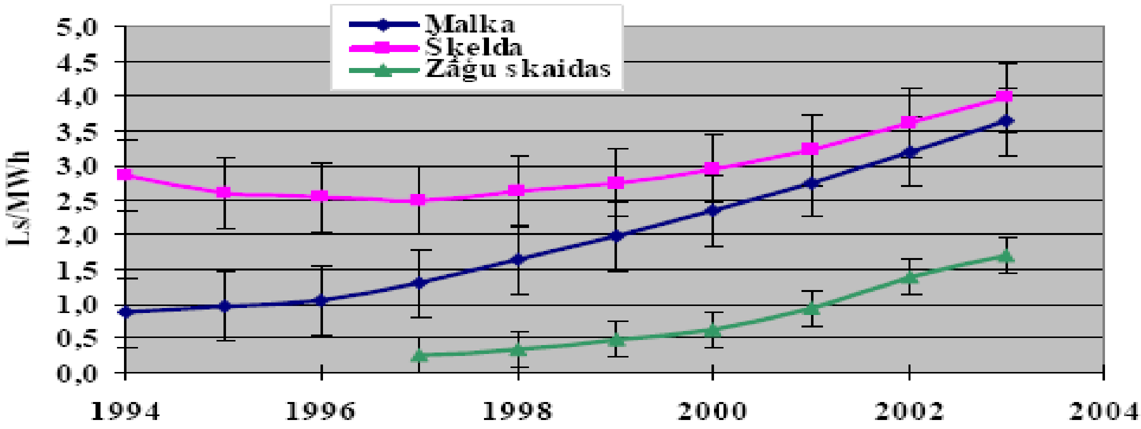
Wood is already used to a large extent today, mainly for heating in the domestic and service sectors and in district heating. It is predominantly waste products from the timber production. It includes firewood, wood pellets, briquettes and wood chips. Production and consumption of wood for energy increased considerably in the last decade, national consumption (TPES) increased from 47 PJ to 59 PJ while production increased from 54 PJ to as much as 83 PJ because of increasing exports. Wood used in the energy transformation (mainly heat plants and CHP) increased from 8.3 PJ in 2000 to 12.9 PJ in 2005. The wood use in 2005 of 83 PJ including exports was higher than the potentials mentioned in the Statement on renewable energy production 2006-2010[8], of 44.5 – 82.5 PJ.

In 2005, a total of 2.311 million tons of wood for energy was exported, but in 2006 export reached 3.282 million tons, which is an increase of 42% compared to year 2005. This fell in 2007 to 2.715 million tons, and 2.402 million tons in 2008, before the trend was reversed in 2009, with an export of 2.893 million tons. Out of the 2.893 million tons exported in 2009, 786.700 tons was firewood (aka 'fuelwood (round)' in the Latvian statistics) an increase of 55% compared to 2008; 1.45 million tons of woodchips (compare with 2.48 million tons in 2005), which is a drop of 7% year-on-year. Export of sawdust and other residues have risen steadily, even through the international financial crisis, and were at 658.000 tons, an increase of almost 25% compared to 2008.[9] Over the same period import of wood for energy increased as well – from 74.200 tons in 2006, to 140.300 tons in 2007 (fuelwood import increased more than 5 times but still remains very low compared to domestic production; import of woodchips fell by 11.6%; but import of wood wastes increased by 44.5%).

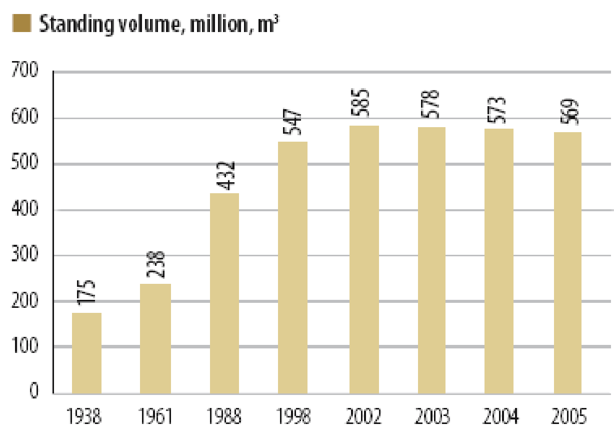
A new estimate of the potential is 108 PJ (30 TWh) of possible wood from existing forest and forest industry.[10] This includes:
-7.6 million m^3 (16.2 TWh) of wood from forest and use of 30% of 1 million ha of abandoned land (i.e. use of 300,000 ha) with a total yield of 650,000 m^3/year or 2,2 m^3/ha.
-4 million m^3 (10 TWh) that are exported today
-3 TWh of secondary wood from industry and wood waste

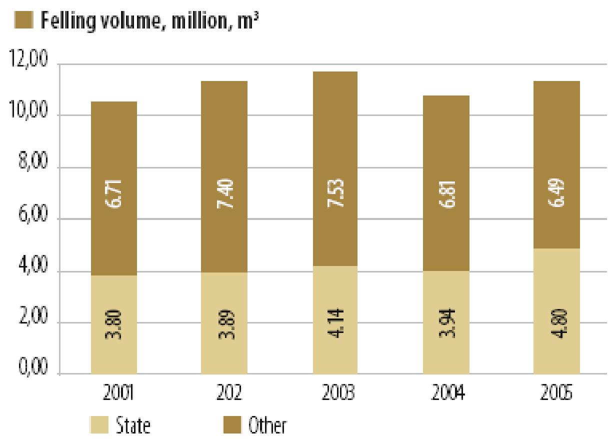
[8] Atjaunojamo energoresursu izmantošanas pamatnostādnes 2006. – 2010. gadam
[9] Ministry of Agriculture, http://www.zm.gov.lv/doc_upl/2008_2009a.pdf
[10] Included in Atjaunojamo energoresursu potencials Latvija, Agency of buildings, energy & housing, Latvian Ministry of Economy, 2008

Prices of energy wood in local marker (Legend: firewood, woodchips, wood waste):



Annually approximately 11 – 12 million cubic meters of wood are harvested. The annual increase of standing crop is 16.5 million cubic meters. At the beginning of 2004 total forest stock was 578 million m^3. During 2004 10.7 million m^3 were cut, which makes 66% of the growth[11]. Development of forest felling and standing volume of forests is given in the graphs below. The decrease in standing forests since 2002 is partly a result of trees falling in storms. Use of wood from these trees is included in the statistics of wood use for energy.





However the data from forestry research institute Silava differs. According to their assessment based on field trials, there are 3313 thousand ha of forest with total standing volume of 629 million m^3. They estimate:

- The annual increase in the forest volume at 25,53 million m^3 annually,
- 60,42 million m^3 of dead wood and 52,04 million m^3 of damaged trees in the forest.

Till now, there has been a little use of wood residues in Latvia. Remains of forestry and forest harvesting amount to approximately 15 – 25% and constitute ~2.53 million m^3 of fuel (technical potential is around 4 million m^3). According to data from Latvia's environmental agency, currently around 2 million m^3 of wood residues are used annually. Potential for fuelwood is also in the wood processing industry, where from 1 m^3 of sawn timber it is estimated to generate around 1-1,5 m^3 of loose wood residues. An Analysis from the Ministry of Agriculture on biomass resources available in Latvia shows that currently approximately 5 million m^3 of fuel wood are not used. From such an amount ~24 PJ of heat energy could be produced a year. Given the high increase in export of wood fuel from Latvia after the study was launched (export increased 950,000 tons from 2005 to 2006, equivalent to about 1.2 million m^3), we only include

[11] State forest service.

2 million m^3 of the above-mentioned 5 million m^3 as additional potential use of wood fuel from existing sources for energy in Latvia. This is equivalent to a potential increase of use of wood fuel from existing sources with 10 PJ.

For this study we use a future production potential of wood for energy of 44 PJ. With the projected energy savings and increases in efficiency, there is no need to develop the full potential for the foreseeable future.
Further increase in the use of wood for energy is expected to come from new plantations of trees, as described below under “energy plantation”. This is 14 PJ less than above-mentioned new potential, but does not include energy plantations on abandoned lands.

There is a potential for straw for energy use in Latvia. Straw from agricultural production is not calculated, so the potential use must be based on assumptions of assumptions of straw production and use in agriculture.

According to the PHARE project from 2000 “Renewable energy resource programme” excess straw production in Latvia, which is not used in agriculture is 150 - 570 thousand tonnes. There are large regional variations with the highest potentials in Zemgale (Southern Latvia next to Lithuania).

If the average heating value of straw is 4.0 MWh/t, then total energy value is 2,2 – 8,2 PJ.

For this study is used a potential of 5-6 PJ of straw from grain.

The increased production of rapeseed will lead to increased production of rapeseed straw. The production of one ton of rapeseed oil, roughly equivalent to one ton of biodiesel, will give 3.9 ton of rapeseed straw with an energy content of 14.5 GJ/ton[12]. The production of 168,000 ton of rapeseed oil (see below) will then lead to a straw production of 655,000 ton with energy content of 9.5 PJ. This potential will be available with the production of rapeseed oil (see below). Straw from rapeseed is less used internationally than straw from grain. Not all equipment for straw firing can be used for rapeseed straw, but technology for its use as fuel is available.
Also the press-cake from the rapeseed can be used for fuel with an energy potential of about 5 PJ for the 168,000 ton of rapeseed oil; but it is also valuable as fodder and is therefore not included as an energy source in this study.

According to a report on energy from Physical energy institute,[13] the potential for straw from grain and rapeseed for energy is about 330,000 tons (3.4 PJ) + 330,000 tons (3.4 PJ) of remaining from cleaning of seeds. This is calculated with 12.5% of the straw production used for energy. Based on Danish experience, the fraction of straw from grain for energy can be increased to 25%. The fraction of straw from rapeseed can be higher as there is no traditional use of rape-seed straw, e.g. for animal bedding. This is why we maintain a substantially higher potential of straw for energy in this report (we use 15 PJ compared with about 7 PJ in the report from Physical Energy Institute).

[12] Rape-seed oil for transport 1: Energy Balance and CO2 balance, Jacob Bugge 9/11-2000, available from www.folkecenter.net

[13] Noslēguma pārskats par projektu «Lauksaimniecības atkritumu enerģētiskās vērtības un izmantošanas perspektīvu analīze un alternatīvo kurināmo izveide»

With this we use a total solid biomass potential is 109 PJ, combining the 94 PJ of wood and 15 PJ of straw including rapeseed straw. Of this 84 PJ is used today (2005), the remaining potential for wood is expected to be used in 2015 and the potential from straw is expected to be used in 2020 and later. The 2005 export of 24 PJ of biomass (wood) is used as future export volume of solid biomass.

Liquid Bio-fuel
To ensure the fulfilment of the EU target of 5,75 % biofuel in the total fuel consumption, by year 2010 Latvia would need to consume 75,000 t of biofuels, for instance 32,000 t bioethanol (1.72 PJ) and 43,000 t of biodiesel (1.4 PJ)[14].

The maximum rapeseed plantations are 180,000 ha according to Latvian Renewable Energy Statement.[15] This will provide 168,000 t of biodiesel, equal to 6 PJ, as well as straw and press-cake. The present area with rapeseed is 83,000 ha (2006) for all purposes.

The liquid biofuel potential is set to 5.5 PJ in this study, of which 3 PJ is expected to be used in 2010 and the full potential in 2020. This can be done with rapeseed, ethanol from grain, or other liquid biofuels. This is a bit below the EU-targets of 5.75% in 2010 and 10% in 2020 of biofuel use in transport fuels. No export or import of biofuels is included in the vision.

In this study we assume that biofuel production will be used domestically. Current barriers to domestic biofuel use have resulted in the export of Latvia biofuel production to other EU countries.

Biogas
Potential streams of wet biomass for biogas were assessed like this in 2004:
-5.8 million ton of manure.
-0.4 mill ton of biodegradable household waste;
-0.034 million ton of animal waste;
-0.18 million ton of active sludge from waste water plants (36,000 ton of dry matter);
-Small amount from food production and processing.

In the biogas production and development programme are plans to construct 13 new biogas electricity-generating stations before 2013. It is also assessed that in Latvia it is possible to produce:
-95 million m^3 of biogas from manure;
-23 million m^3 of biogas from biodegradable household waste;
-23 million m^3 of biogas from food production and processing waste;
-16.8 million m^3 of biogas from green mass (leaves etc.);
-10.8 million m^3 of biogas from active sludge from waste water plants;
-10.65 million m^3 of biogas from animal waste.

From this amount it is estimated that the production can be 290 million m^3 biogas or 5 PJ energy and fertilizer for agriculture.[16] In the Biogas strategy[17] there is estimated to be 174 million m^3 biogas annually or 3 PJ energy.

[14] Programma “Biodegvielas ražošana un lietošana Latvijā 2003-2010”
[15] Atjaunojamo energoresursu izmantošanas pamatnostādnes 2006.– 2010. gadam
[16] SIA Agito. Biogāzes ražošanas iespējas Latvijā. Rīga, 2005
[17] Biogāzes ražošanas un izmantošanas attīstības programma 2007.-2011. gadam

In a new estimate,[18] the total potential is given as:

Cattle manure:	0.193 TWh
Pig manure	0.119 TWh
Poultry manure	0.129 TWh
Wastewater, food waste	0.138 TWh
Landfills	0.138 TWh
Unused plant materials	0.12 – 1.2 TWh
Other	0.1 TWh

(Total: 1 – 2 TWh)

It is estimated that based on this potential, biogas plants with a combined capacity of 300 MW-electric can be installed. This is equal to an energy production of 4.5 TWh (16 PJ), excluding energy needed for the biogas process.

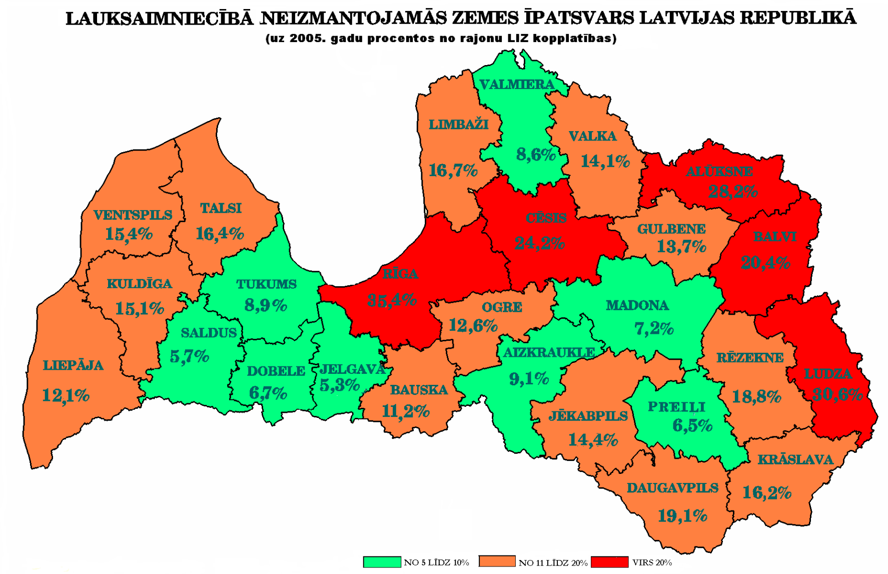
Currently total installed capacity of biogas in Latvia is 7.786 MW, which is producing electricity and heat from gas from landfills and sewage sludge.

We expect a fast development of biogas, resulting in 2.7 PJ used in 2020. More could be used later, but is not included in the current vision.

Energy Crops for Solid Biomass

Our proposal for energy crops for solid biomass is to use a fraction of the unused agricultural land. It is estimated that 14,9% of the agricultural land, 363 505 ha (3635 km^2), in year 2005 was not used for agricultural production[19]. This land is not cultivated for at least last two years but can be used for energy crops such as short rotation coppice with willows or poplar, elephant grass (*miscanthus*), or others. Of this land 51,000 ha is overgrown with bushes.

Unused agricultural land in proportion to agricultural land in Latvia's Regions:



[18]Included in Atjaunojamo energoresursu potencials Latvija, Agency of buildings, energy & housing, Latvian Ministry of Economy, 2008

[19] Assessment done in 2005 by „ Latvian Rural Consulting and Education Centre".

In 2005 in Latvia there were 30-50 ha of willow (salix) plantations[20]. Most of them are eliminated by now, because there is no agricultural support (area payment) for this, but it is expected that such payments could be introduced, following EU rules for energy crops (payment 45 Eur/ha). However there are several field trials. One of them is in Olaine.

In Sweden the average yield for sallow (willow, salix) plantations is 6-8 t of dry matter/ha, with felling every third year of 18-24 t of dry matter/ha. Experience in Latvia shows that for willow grown in fallow land on sandy soils, the annual yield is a minimum of 5t/ha. In fertile, good cultivated soils the annual yield could reach 15-16 t of dry matter/ha.

In this study we assume an average yield of 7 t/ha and an available area of 340,000 ha, assuming that some of the unused agricultural land is not used because the owners plan to convert it to urban developments within a few years. With an energy content of 4.9 MWh/ton[21] of dry matter, the corresponding energy potential is 34.3 MWh/ha or for the area of 340,000 ha 11.6 TWh = 42 PJ. Similar yields can be achieved with other fast-growing trees such as poplar and elephant grass (miscanthus). This yield is substantially higher than the one in the new estimate of biomass [22], where the yield of 2.2 m3/ha = 1.5 ton of dry matter pr. ha is 5 times lower.

We expect the development of energy plantation to take off after 2010 and that 60% of the area is utilised by 2020 and later, equal to 200,000 ha.

Geothermal energy

The main geothermal resources are based in the Riga region and South-Western part of Latvia in the depth of 1300 – 1950 m. According to Latvian Renewable Energy Statement 2006 the temperatures are in the range of only 25-30'C[23] and covering 12 000 km^2, but according to EBRD, the temperatures are in the range of 30-65'C. Because of the problems with extracting useful energy from such resources with low temperatures, use of geothermal energy is not included in this study.

[20] http://www.zm.gov.lv/doc_upl/Iscirtmeta_energetiskas_koksnes_plantaciju..._Silava.pdf

[21] Biomass includes humidity and the calorific value depends on this. As an example coniferous wood with 40% humidity has a lower calorific value of 2.9 MWh/ton, but relative to the dry matter content (60%) the lower calorific value is 4.8 MWh/ton. For beech wood with 20% humidity the lower calorific value is 4.1 MWh/ton and relative to the dry matter the lower calorific value is 5.1 MWh/ton. For straw with 15% humidity the lower calorific value is 4.0-4.2 for different types of straw and relative to its dry matter content the lower calorific value is 4.7 – 4.9 MWh/ton. As an average the (lower) calorific value is set to 4.9 MWh (17.6 GJ) / tons of dry matter.

[22] Included in Atjaunojamo energoresursu potencials Latvija, Agency of buildings, energy & housing, Latvian Ministry of Economy, 2008

[23] EBRD, Country report 2005.

Hydropower
Production of large hydropower was in 2790 GWh in 2005 and of small hydropower 58 GWh (3100 h/ year). The potential for additional hydropower is not assumed to be acceptable for environmental reasons. Use of hydropower had shrunk by 0.7 PJ in 2008 relative to 2005, and is expected to stay at that level. In 2010 the estimate is that the hydropower production will be very low, but that is expected to be temporary.
We have not included expansion of the hydropower capacity.

4. Efficiency Potentials

For the vision it is assumed that the efficiency can be increased a factor 4-10 with known technologies. This has been shown to be possible for Western European energy consuming sectors, see e.g. "Factor 10 Club" (www.factor10.de). Even though the increase of efficiency is cost effective when introduced gradually with exchange of equipment, it will not happen by itself, as the decision-makers, e.g. the designers and manufacturers of equipment are not dedicated to supply and install energy-efficient products for a number of reasons. The increase in efficiency can be measured as decrease in the specific amount of energy used to provide a certain energy service (heated floor space, transported persons or amount of goods, amount of industrial production, use of electric appliances etc.)

For transport, electric appliances, and industrial production, energy consuming vehicles and equipment will be changed several times during the more than 40 years that the vision covers. Thus, there are not technical limitations to raise the efficiency a factor of 4 or more. The following increase in efficiency is included in the vision for industrial appliances (heat, fuels and electricity), electricity and road transport to reach a factor 4 efficiency increase 2000 – 2050:

- 2000 – 2010 5% in total*
- 2010-2020: 2% p.a.
- 2020-2030: 3% p.a.
- 2030-2040: 4% p.a.
- 2040-2050: 4.4% p.a.

* For industry, private and public sectors efficiency increases 2000 – 2010 are 8-10%, based on preliminary statistics; for personal cars the efficiency was going down 2000-2010, about 4% based on preliminary data.

There seems to be no increases in efficiency 2000 – 2010 for road freight.
Combustion engines (15-20% efficiency) still dominate transport, electric vehicles (about 80% efficiency) remain expensive (although they are very slowly starting to become more available) and hydrogen fuel cells (>60% efficiency) have yet to be a viable commercial alternative. Still, we have included the above mentioned efficiency increases from 2015 onwards, assuming rapid development of electric and hydrogen fuel cell engines at a price sufficiently competitive to ensure adoption of these technologies at the pace needed.

For domestic and service electricity use, high efficiency increases are expected because of ongoing rapid replacement of appliances and vehicles.

The expected increases in efficiencies will only happen with working energy efficiency policies in place from 2010. The longer such policies are put off, the faster the changes will have to be and therefore also more difficult to fully implement on the timescale available.

For agriculture, construction, rail and water transport the following efficiency increases are included until 2050: 40% for agriculture and 50% for construction, 65% for rail transport (partly achieved with electrification), and 25% for navigation (although this is not included in the study). Also for these sectors the start is expected to be slow: 5% increase 2000 – 2010 for agriculture and construction. The expected increases in efficiency for road and rail transport, may not necessarily happen at the projected pace either, but are possible if progressive, proactive policies are in place.

Manufacturing sector

Current industry in Latvia is not very energy intensive. In the vision is included a large growth in these sectors for 2000 - 2010 (see below chapter 5 in activities in society).

Official energy intensity estimates in Latvia (TOE/1000EUR(2000))[24]:

2004	2010	2013	2015	2020
0,41	0,35	0,31	0,28	0,22

According to the EU Action Plan for Energy Efficiency, energy efficiency until the year 2020 will have to increase by 1.5% annually compared with value added to reach EU target of 20% saving in 2020[25]. In Latvia, SIA Baltijas Konsultācijas did a study on potential developments in manufacturing industry until 2020, in 2007. According to this study, energy intensity in the sector has decreased by 15% in the period 2000-2006 compared with value added (about 2.5%/year). Productivity in the sector historically increased from -33% to +10%, but on average +0.36% annually. Forecast is that the same trend will continue till 2020. No data is available on the relation between energy consumption and the volume of production, which is the energy service parameter used in this study; but we expect that improvements are lower than the 2.5% annual decrease in energy consumption relative to value added.

In the visions we will use the assumption that efficiency increased 1%/year 2000 – 2006 relative to volume of production and that this trend will continue until 2010. From 2010 it is assumed

[24] Statement on energy development 2007. – 2016

[25] Communication From The Commission, Action Plan for Energy Efficiency: Realising the Potential, COM(2006)545

that efficiency will speed up to 15%/year 2010-2020 and then increase further to reach a factor 4 increase 2000 – 2050. This is used for efficiency of both heat and electricity demand.

Latvian statistics on heat demand from industry, construction and agriculture, do not treat industry and construction as two separate sectors.
Data from the Central Bureau of Statistics (EN12) show a sharp decline in industry/construction heat demand from 2007 to 2008, the eye of the financial storm. As no newer data is available, data from 2008 will be used for the year 2010.

Efficiency of heating

In Latvia, total heat consumption of dwellings was 55 PJ in 2000, including domestic use of fuels. Energy consumption in centralized heat production has decreased from 37.9 PJ (10527 MWh) in 1995 to 24.7 PJ in 2000 and has been stable since then. Local heat production in commercial sectors has increased substantially 2000 – 2004 from 36.6 PJ to 46.7 PJ, driving up total heat demand.

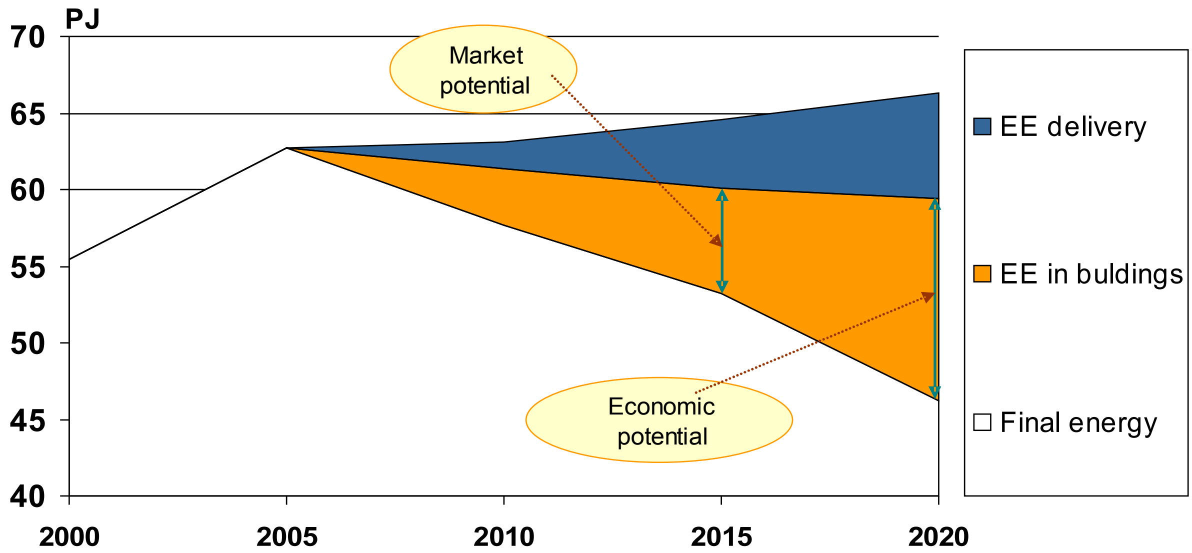
In Latvia there is very low energy efficiency in buildings. In Riga, final energy demand for heating (including internal losses in buildings) is assessed to be on average 231 kWh/m^2/year, and in the rest of the country 220-250 kWh/m^2/year[26]. Also the heat losses in the district heating networks are high. The district heating losses have been reduced, but they are still around 5 PJ, equal to 20% of district heat consumption.

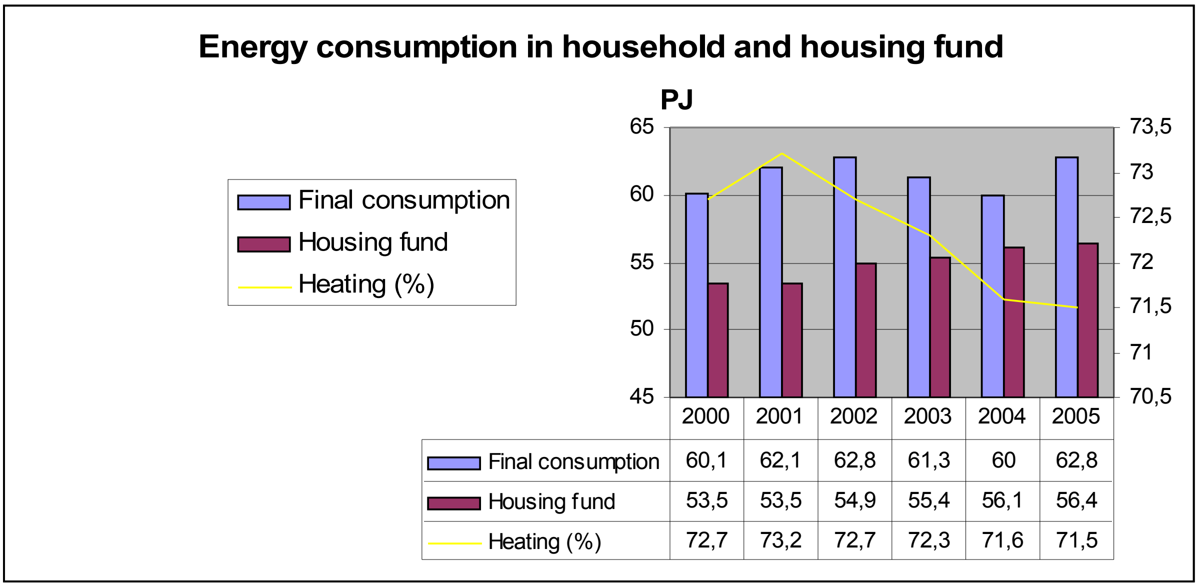
Statement on energy supply 2006-2016 sets the goal that until 2016 average final, specific energy demand for heating should be reduced from 220-250 kWh/m^2/year now to 195 kWh/m^2/year and until 2020 should reach the average of 150 kWh/m^2/year.

By realizing market potential and decreasing energy consumption to 195 kWh/m^2/year it is possible to save 7 PJ energy, but by realizing economic potential and decreasing energy consumption to 150 kWh/m^2/year it is possible to save 15 PJ energy, according to the study "Energy efficiency in buildings" done by Institute of Physical Energetics, Laboratory of Energy system analyses and optimisation.

[26] AS „Latvenergo" un AS Rīgas siltums publiskie gada pārskati.

Energy efficiency potential in buildings, following statement on energy supply:





	2000	2001	2002	2003	2004	2005
Final consumption	60,1	62,1	62,8	61,3	60	62,8
Housing fund	53,5	53,5	54,9	55,4	56,1	56,4
Heating (%)	72,7	73,2	72,7	72,3	71,6	71,5

After 2020 we assume continued efforts for energy efficiency in line with further implementation of EU regulation and increasing energy prices, leading to an increase of building efficiency of 2%/year. This is similar to the assumptions for INFORSE-Europe sustainable energy visions for Western Europe.

There are no data on the division of heat losses in heating systems, including boilers inside houses and heat consumption to hot water and space heating. In this study we assume that the losses in heating systems inside houses including losses in boilers is 25% in 2000 and that it will gradually decrease with 5%/decade until efficiency reaches 90% in 2020. Then the increase in efficiency will only be 1%/decade.
With these assumptions, the improvements in the first decades will mainly be in the heating systems while the remaining efficiency gains resulting from building improvements.

This gives the following development in heat efficiency parameters, combining space heating and heating of hot water:

Specific heat demand in Latvian buildings	2000	2010	2016	2020	2030	2040	2050
Final spec. heat demand (kWh/m2)	230	210	195	150	123	101	83

It can be difficult to realise the sharp increase in efficiency 2016-2020; but the overall improvement decade by decade seems reasonable, on the assumption that special initiatives are carried out for the period 2010-2020, e.g. with EU support, building codes, loans for improvement of houses (mortgages), and not the least: rebuilding of a large part of the inefficient apartment blocks from the Soviet era. For the vision only data sets for the start of each decade are included, the data for 2016 in the table above are not used.

This development is used for space heating of domestic buildings as well as in the service sectors.

While the relative increase in efficiency from 2000 to 2050 is large, the target of 83 kWh/m2 is not ambitious compared with plans for Western Europe, e.g. for Denmark.

Efficiency in Energy Supply

For energy supply we expect an increase in the conversion efficiency in the electricity and heat sector, leading to a decrease in the average loss in power and CHP plants.

Statement on the energy supply 2006-2016 sets targets for heating system efficiency and losses. Average efficiency for heat and CHP stations 2016 should be improved from current 68% to 80%-90%.

From the low efficiency in the CHP plants in 2000 are expected increases already in 2010 with the new gas-fired power plant in operation from 2008 in Riga[27].

We use the following efficiencies for thermal power plants in the vision:

Power plant efficiencies	2000	2015	2020	2030	2040 and later
Electric	20%	38%	45%	46%	47%/55%*
Heat	52%	40%	40%	39%	39%/0
Total	72%	78%	85%	85%	86%/55%

* For 2040 and later is included power production on power-only plants.

The electric efficiencies after 2010 are based on power plant efficiency data used for Danish energy planning for new plants (Danish Energy Authority, "Technology Data for Electricity and Heat Generating Plants" from www.ens.dk), phased in over the period. The Danish energy efficiencies data are:

Power plant efficiencies, new plants*		2010	2020 and later
Gas-fired combine-cycle, 100 – 400 MW	Electric (at 100% load)	58-62% (no heat prod.) 53-58% (full heat) 6% lower at 50% load	59-64% (no heat prod.) 54-60% (full heat) 6% lower at 50% load
	Total (at full heat)	90%	91%
Gas-fired combine-cycle, 10 – 100 MW	Electric (at full heat)	47-55% (100% load)	48-56% (100% load)
	Total (at full heat)	90%	91%

[27]The new combined-cycle 400 MW block is expected to have an electric efficiency of 50% in CHP mode and to produce 60% of CHP power production in Latvia in 2010.

Gas engine 1-5 MW	Electric	41-44% (100% load)	as 2010
	Total	88-96%	as 2010
Large biomass-fired steam turbine plant, 400 MW	Electric	46.5% (100% load) 2.5% lower at 50%	48.5% (100% load) 2.5% lower at 50% load
	Total	90%	as 2010
Straw-fired steam turbine, 5-15 MW**	Electric	29-30%(>75%load)	as 2010
	Total	90%	as 2010
Wood gasification, 1-20 MW	Electric	35-40% 5% lower at 50% load	37-45% 0-5% lower at 50% load
	Total	103%***	103%***

*Net efficiencies, adjusted for own consumption
** Larger installations have larger electric efficiencies
*** With flue gas condensation

The electric efficiency of the plants in 2020 (45%) can be achieved with 20% of production on combined-cycle gas-fired power plants with 58% electric efficiency, 55% on large biomass plants with 48% efficiency and 25% on smaller biomass plants with 30% efficiency.

The heat efficiencies are below the plant characteristics, as the plants will not run with full heat production during the whole year.

For heat producing plants, efficiencies are expected to increase 5%/decade from an average of 78% in 2010 (2008 data) to 90% in 2025 and then remain stable.

According to the Statement on energy supply 2006-2016, the losses in heat transmission by 2016 should be reduced from 18% now (2005) to 14% of production. They were 19% of production (24% of consumption) in 2000. We expect these losses to be 18% of production in 2010 and to be reduced to 14% of production (17% of consumption) in 2020 and then remain stable.

Also the efficiency of the electricity network can be expected to increase. We expect that the grid losses are reduced from the very high figure of 19% of supply (22% of consumption, statistics for 2000) to 13% of production in 2010 (realised in 2005 according to statistics) and further to 9% of production in 2020 and then remain stable on that level.

5. Demand for energy services

This model does not include an assumed correlation between economic development (GDP growth) and energy consumption. Instead it's expected that growth in energy consuming factors, such as heated floor area, transport and production will increase in volume, not in value. These drivers are referred to as energy service demands.

"Rigas siltums", the main heat service provider in Riga City, is forecasting heat demand increase in Riga over the next 5 years by 580-600 MW. This is, if all the new development projects in Riga are realized, which, given the financial crisis and the sharp downturn in real estate, probably won't happen. Rigas siltums over the next 5 years is planning to increase its capacity by 50-60 MW annually.

The demand for energy services (heated floor space, transport etc.) is expected to increase as follows:

Heating (district heating + fuels):
Energy consumption for heating of dwellings has increased 6% in the period 2000 – 2005[28].

The development of housing and construction of dwellings is developing according to the statistics below:

Construction of dwelling-space in Latvia 1990. – 2004.g. (LR CSP data)

	1990	1995	2000	2001	2002	2003	2004	2005
Total housing fund mill.m^2	52,9	52,7	53,4	53,5	54,9	55,4	56,1	56,4
in cities	33,8	34,1	34,7	34,8	35,7	36,2	36,5	36,8
In countryside	19,1	18,6	18,7	18,7	19,2	19,2	19,6	19,6
Average for inhabitant, m^2	19,2	21,4	22,6	22,8	23,6	23,9	24,3	24,6

The development of dwelling area is an increase of 6% in the period 2000 – 2005 (3.0 mill. m^2 increase relative to 53.4 mill. m^2 in 2000), equal to 1.2%/year.
This increase in dwelling area follow the increase of consumption of heat and fuels in dwellings of 6% 2000 – 2005 (from 51.4 PJ to 54.3 PJ), and thus there is no effect to be seen of energy efficiency.

We expect that the increase in dwellings will be a bit faster than in the period 2000 – 2005, increase from 1.2%/year to 2%/year and continue this development until 2030, where it will level off to a net increase of 0.5%/year. In this way the area in 2050 will be 180% of the area in 2000, and the dwelling area per capita will then be 38.6 m^2. It should be noted that while the boom before the crisis sped up development past the projections, it remains a possibility that future growth could stagnate or even become negative. Furthermore, *real* growth in area per capita has been an average of 1.8% per year in the period 2000-2009 rather than the assumed 2%. Should this continue, average area per capita will be 35.2 m^2 in 2050.
While the overall area has increased in the 2000-2009 time span, public space has *declined* by about 54%; a trend that seems set to continue, though it may very well level off at some minimum.[29]

Consumption of heat and fuels of service sector buildings has increased 24% 2000 – 2005[30].
With the assumption of no increase in efficiency in the same period as seen for dwellings, the area of service buildings has increased 24%, equivalent to about 4.8%/year. This increase is expected to continue until 2015 and then level off to 2%/year until 2030 and then 1%/year. In this way the area in 2040 will be 3 times the area in 2000.

Agriculture is expected to continue the same level of activity that it had in 2000, measured in product volume that drives energy consumption.

Industry energy consumption increased 24% 2000 – 2005, driven by a 17% increase in electricity use, 41% increase in use of natural gas and a 2.4 times increase in biomass use. It is assumed that growth is 5% higher given the increase in efficiency discussed above. It is further assumed that

[28] From Latvian energy statistics for 2000 and 2005 respectively, both from the 2006-publication from Central Statistical Bureau of Latvia. The data is used with one change: in the statistics diesel oil consumption in households is gives as 0 in 2000 and 1105 TJ in the years 2001-2005. This seems to an error and therefore diesel consumption in households is set to 0 for 2005, to make the best comparison with 2000.
[29] Calculations in this section is based on data obtained from the Central Statistical Bureau of Latvia's online database
[30] From Latvian energy statistics for 2000 and 2005 respectively, both from the 2006-publication from Central Statistical Bureau of Latvia. Data for other sectors as there is no category for service sector.

this growth will continue until 2010 with the same rate: 49%/decade for production requiring electricity and 66%/decade for production requiring heat and fuels. The *actual* growth of energy demand will be lower because of efficiency as explained above. We assume that the growth of production will stop in 2010, after which increased value in Latvian industry will come from improved quality instead of increased quantity, following Western Europe. Two changes of major industries are included:

- The new CEMEX cement kiln will increase industrial electricity consumption about 120 GWh/year. This is less than the expected increase in electricity consumption of "other industries" 2000 – 2010. The increased fuel demand for the new kiln will mainly be from waste materials and will therefore not influence fossil or renewable energy demand, but is not included.

- The change of the steel smelter from gas to electric arc furnaces is included with a decrease of gas use of the "iron and steel" industries with 4.4 PJ and an increase of the sectors electricity use of 3.6 PJ. When the electricity increase is lower than the gas use decrease it is based on the assumption that electric arc furnaces are 20% more efficient that gas furnaces for steel smelters.

Construction has doubled in 2000 – 2005 according to statistics for construction of dwellings, so we assume that the sector's energy demand has doubled. It is expected to remain constant on the current higher level.

<u>Electricity:</u>
Household Sector: Household electricity demand increased 32% 2000 – 2005. Part of this is caused by a move to electric heating, including electric water heating, both in new houses outside areas supplied with gas and in areas supplied with district heating. There is no information about the size of this increase, and it cannot be seen in heat statistics, as it is less than inter-annual variations in heating because of weather.

In this study we assume that policies are put in place from 2010 onwards, to stop the expansion in electric heating. While electricity consumption in households 2000-2010 did surpass previous expectations, we expect that after 2010 the increase in demand for electricity services will be 10%/decade above increase in living space until 2030, assuming that the trend towards electric heating will be stopped or reversed (increase of 47% 2010-2020 and 24% 2020-2030). After 2030 we expect the growth of electricity service demand will follow growth in household area. This will lead to an electric energy service level in 2050 of 3.12 times the 2000 level. We do not propose use of heat pumps for heating as they do not benefit the Latvian energy system; priorities are district heating and biomass.

<u>Service sector</u>: Service sector electricity demand increased 39% 2000 – 2005 or 15% higher than the increase in heating in the sector.

We assume that the high growth is partly caused by increased use of electric heating, and that the growth of electric heating is stopped. Then electricity service growth 2005-2010 is expected to be 5% higher than the growth in heated service area 2005-2010, which is expected to be 24%, so the total growth 2000 – 2010 will be 68%. We assume that there will be a growth of electric energy service demand equal to heated floor space in the sector (which is 2% p.a.) + 10%/decade in the period 2010-2020. Then we expect electricity service demand increase to follow increase in the area of heated floor space. This will lead to an energy service level for electricity using equipment in 2050 of 4-4.5 times the 2000 level.

Industry: We assume an increase of 35% per decade (3.5%/year) until 2020, following trends 2000 – 2005, at which point demand will stabilize.

Agriculture: We assume a decline of 10% in the decade of 2000-2010, at which level it will stabilize.

Construction: We observe an increase in demand of 20% in 2005 relative to 2000. This is expected to decline to around 113% of 2000 demand, grow to 116% of 2000 demand and then remain constant.

Compared with the forecasts of Latvenergo, this forecast for power consumption for 2010 is equal to Latvenergo's figure (mentioned on page 2); but the forecast for 2020 is significantly lower than extrapolation of Latvenego's forecast for 2016 to 2020 (the forecast for 2020 is almost equal to Latvenergo's forecast for 2015). The main difference between the forecasts for the period after 2010 seems to be our assumption that growth of electric heating is halted.

Transport: Transport has increased in recent years and fuel use of road transport increased 40% 2000- 2005, with almost all of the increase in diesel oil use. The following statistical increases are all from Latvian ministry of transportation, statistics available online from ministerial website, Latvian version.

Bus passengers increased from 165.9 million in 2000 to 214,1 mill. in 2005 but decreased again to 209.4 mill. in 2006. There is no specific data on fuel consumption of buses, instead we use the estimate that 10% of diesel consumption is used for buses. The increase 2000 – 2005 is 33%. However it now appears that the peak year in number of both bus passengers and kilometres travelled was 2005, as it has been declining up till 2009, even going below the 2000-level. That said, in 2009 a new electronic ticket system was introduced, which (at least temporarily) caused a sharp decline in the number of registered passengers (and therefore also the total of kilometres travelled by those passengers), meaning the observed decline may appear overly dramatic. To correct for this, we use 2008-data as proxy for 2010. We assume the decline will stabilize at around 110% of the 2000-level until 2020 and then continue its previous upwards momentum, albeit at a much slower pace. After 2020 the increase is assumed to be 10%/decade until 2040 and then stable on 1.48 times the 2000-level.

Use of passenger trains increased from 715 million passenger-km in 2000 to 892 million passenger-km in 2005 and 992 million passenger-km in 2006, an average increase of 5.6%/year, BUT 11% 2005-2006. Much like passenger-km for bus transport, a peak can be observed, and 2006 was that peak. In the 1990s, use of passenger trains fell dramatically to less than 1/3 of the previous level, but started to grow again in 2001. The increase of 5.6%/year observed in the period of 2000-2006, appears much too high given the subsequent decline and the ongoing economic turmoil. In an attempt to correct for this, we now expect passenger-km to return to 2008-level in 2015, and grow 1% p.a. from then on. With this development, passenger train use in 2050 will be 1.8 times the 2000-level, though still a far cry from the heyday of Soviet passenger rail transport in the 1980s.

Passenger cars increased from 556,771 by 2000 to 932,828 in 2008 – which may in hindsight turn out to be the peak year, as the number of cars fell to 904,308 in 2009, a decline of 3.1%. Up until then, there had been a roughly 7% p.a. growth on average during 2000-2008. We expect the decline to halt at the 2009-level and growth in number of cars to resume at 1% p.a. until 2020, when there will be 996.000 cars, fairly close to the EU-15 average of 520 cars/1000 inhabitants. The number of cars is assumed to remain constant from 2020.

With these forecasts, it is expected that Latvia will follow a (more or less) European path leading to a diverse transport sector with many types of transport, not a US-like path with mainly use of personal cars.

It is assumed that passenger-km per car is unchanged, so the number of personal cars can be used as a proxy for car use (and as passenger-km for cars does not appear to be available, this will have to do in any case). The increase of petrol use was only 1% 2000 – 2005 while increase in number of cars was 35%. This is not caused just by increase in efficiency; but by a general shift from petrol to diesel vehicles as a lot of used cars with diesel engines have been imported from Germany. At the end of 2000 59% of buses and 57% of trucks operated on petrol, but these fractions have gradually decreased to respectively 38% and 36% in April 2007. In this study it is expected that the low increase in petrol use is caused by a 10% increase in car efficiency combined with a change from petrol to diesel vehicles.
The increase in number of cars has slowed and reversed as a consequence of the financial crisis. Relative to 2000, activity in 2008 was 167 and fell to 162 in 2009. We expect the activity to grow roughly 10% until 2020, at which level it will stabilize.

This gives the following development of personal transport relative to 2000:

Personal transport	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Car	100	133	162	171	179	179	179	179	179	179	179
Bus	100	123	107	109	110	116	122	128	134	141	148
Rail	100	125	129	133	140	147	154	162	171	179	188

Air transport not included in this vision, but development of internal air transport in Latvia is not included as an option.

Rail freight increased steadily from 13310 million ton-km in 2000 to 19779 million ton-km in 2005, but then decreased to 16831 million ton-km in 2006, before increasing to 19581 mill ton-km in 2008, which then fell once again to 18725 million ton-km in 2009. The average increase 2000 – 2006 is 4%/year. We assume that the decline 2005 – 2006 is temporary and that the average growth of 4%/year will continue in the decade of 2010-2020, after which we assume an increase of 2%/year until 2040 and then no further growth. Rail freight will then be about 1.5 times the 2000 level.

Road freight increased from 4789 million ton-km in 2000 to 8547 million ton-km in 2005 and 10936 million ton-km in 2006. This is an increase of almost 15%/year; but the increase in 2006 was 28%. The peak for road freight (at least for the time being) appears to have been 2007 at 13142 million ton-km, and it fell to 8115 million ton-km in 2009, a drop of 38% from the peak year of 2007. A decrease had been expected, as the large increase 2000 – 2006 was simply not sustainable and much larger than the economic growth of Latvia could justify. The decline came sooner than previously expected, but we now assume it will continue to decline at around 5% p.a. until 2020, where it will stabilize at just 1% above 2000-level.

Freight transport	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Road	100	178	169	131	101	101	101	101	101	101	101
Rail	100	140	141	144	146	148	149	151	152	152	152

Pipeline use: Energy use for pipelines fell 24% 2000 to 2005. It is assumed that it will remain unchanged from 2005 until 2050.

6. Fuel shift

Fuel shift is in general limited to max 3%/year increase or decrease for a specific energy source in a specific sector, but the total can be more as more fuel shifts can happen simultaneously.

Average unused potential for centralized heating system in Latvia is 550 MW_{th}[31]:

- Cogeneration potential in Riga - 50 MW_{th}[32];
- In biggest Latvia's towns – 250 MW_{th} (Daugavpils – 100 MW_{th}, Liepaja – 80 MW_{th}, Ventspils – 40 MW_{th}, Rezekne – 30 MW_{th});
- Other towns with population more then 4000 inhabitants – 250 MW_{th}.

In heating is assumed that district heating is increasing after 2020 from currently 36% of household heat demand and 37% of service sector heat demand till respectively 48% and 48% of the demand of each of these sectors in 2030. District heating is expected to increasingly come from CHP instead of heat only plants, leading to 52% of district heating coming from CHP in 2020 and 85% in 2050 (current level is 37%).

Fuel shift in transport is starting with introduction of biofuels in road transport, initially using about 68 of the bioliquids potential for road transport in 2020 (5.5 PJ), covering 17% of road transport fuels.

In 2030 we expect that railways will be more electrified, covering 68% of rail transport (from 23% in 2020 and 5% in 2000) while we also expect that electricity will cover 20% of energy demand on roads, via the use of electric vehicles.

In 2040 we expect that the use of electricity in rail and road transport will increase to respectively 100% and 70%. We do not expect hydrogen to play any significant role in the Latvian transport sector, as there is simply no need with the large potential for development of various liquid biofuels.

For road transport, electrification is expected to peak around 70% in 2040, but then drop to 55% in 2050 when 45% of supply will be met with domestic biofuels production.

Fossil Fuel Production

The small coal production of 0.7 PJ in 2000 was reduced to 0.12 PJ in 2005 and is not expected to continue until 2010. The use of peat in CHP stations is expected to be replaced by biomass use. There was no production of oil or gas in Latvia in 2000 and in this vision this is not expected to change.

[31] Latvijas Siltumuzņēmumu asociācijas, AS „Rīgas siltums", AS „Latvenergo" informācija.

[32] Šī potenciāla apgūšana neatstāj ietekmi uz esošo koģenerācijas staciju darbības režīmiem, jo to siltumapgādes zonas savā starpā nav savienotas.

International Energy Trade
The current export of biomass and import of fossil fuel is expected to continue. While the biomass export is assumed to be constant, fossil fuel imports are expected to grow 2000 – 2010 because of increased consumption and replacement of imported electricity with domestic electricity. After 2010 fossil fuel imports are expected to decline, in particular gas imports as gas is replaced by biomass.

Electricity import, currently 30% of electricity supply is expected to end by 2010 with power supply taken over by windpower that replaces about 40% of the import (import was 6.4 PJ in 2000, windpower is expected to produce 2.5 PJ in 2010) and increased use of power plants, in particular gas fired power plants. Before 2020 most of the power production is expected to come from biomass fired CHP and power plants. After 2040 electricity export could be an opportunity, if the efficiency potentials are realised.

Energy storages
High reliance on intermittent renewable energy – wind and solar- will require efficient energy storage and flexible energy use. The total fraction of intermittent electricity production in 2020 is 15% rising to 16% in 2050. To cope with this, the regulation capacity of the hydropower plants and thermal power plants can be used. The hydropower plants have a storage capacity of about 57 GWh, equal to about two days of average expected power demand in 2020[33]. There is no need for special storage of electricity in the system, given this low fraction of intermittent power (The Western Danish electricity system that is larger than the Latvian electricity system already has about 24% of electricity from windpower integrated in the power supply.)

In the electricity sector some flexible consumptions are also introduced:

- Hydrogen production for transport.
- Electric cars with batteries that can be charged at different times at night

For the CHP plants we recommend daily/weekly heat storages (water tanks) to de-couple electricity and heat deliveries on a short-term basis.

For solar heating there will be some need for seasonal storage from 2040 when solar thermal is expected to cover more than 10% of space heat demand outside district heating areas, and after 2040 also in service sector buildings.

About this note
This note was developed by Gunnar Boye Olesen, INFORSE-Europe in cooperation with Alda Ozola-Matule Latvian Green Movement and Janis Brizga from Green Liberty, Latvia, for the Vision2050 for Latvia. Read more about the vision for Latvia and for other countries at www.inforse.org/europe. Please send comments to ove@inforse.org.

[33] Expected power demand 10700 Gwh incl. Energy sector own consumption and grid loss in 2020, equal to 1.24 Gwh/hour in average. 57 Gwh of storage is then equal to 45 hours of average consumption.