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Zaļā brīvība

SUSTAINABLE ENERGY STRATEGY FOR LATVIA'S: VISION 2050

Gunnar Boye Olesen, INFORSE-Europe

Janis Brizga, Green Liberty

2007

About this Vision

This document was developed by Gunnar Boye Olesen, INFORSE-Europe in cooperation with Janis Brizga, Green Liberty as part of the international project Baltic-Nordic cooperation for sustainable energy funded by Nordic Council of Ministers.

Vision 2050 consists of 3 parts:

When no other **sources** are given, the following sources are used:
- use of renewable energy and increase of energy efficiency in Latvia "Vision for a sustainable energy development for EU – 25, 2000 – 2050"
- A vision for Latvia based on INFORSE's Vision2050: Background note, INFORSE-Europe.
- costs and efficiencies "Technology Data for Electricity and Heat Generating Plants" by Danish Energy Agency and others, March 2005. Available from www.ens.dk

Please send comments to:

Gunnar Boye Olesen **INFORSE-Europe Secretariat** Gl. Kirkevej 82, 8530, Hjortshøj, Denmark T: +45 86227000 T/F: +45 86227096 E: ove@inforse.org WEB: www.orgve.dk	Janis Brizga Green Liberty Meža iela 4, LV-1048, Riga, Latvia T/F: +371 67613806 E: janis@zb-zeme.lv WEB: www.zb-zeme.lv

The work on this note and the sustainable energy vision for Latvia is partly paid by funding received from the Nordic Council of Ministers; but it express the findings and the views of the authors and of INFORSE-Europe and not necessarily of the Nordic Council of Ministers.

Read more about the vision for other countries at www.inforse.org/europe.

Latvian Vision for Sustainable Energy

This paper describes a Latvian Sustainable Energy Vision. It includes a transition of the energy supply and demand with phase-out of fossil energy and energy imports over a 50-year period. If this vision is turned into reality it will have a number of positive effects for Latvia that is fully dependant on imports for its fossil fuel supply. With a transition to domestic energy sources, Latvia will no longer be hurt directly by the energy prices increases of fossil fuels that many expect will come as a result of the dwindling resources of fossil fuels. With realisation of the vision, Latvia would also be in the front in the reduction of climate change, a position that can be very valuable in the future. Further, the emphasis on local resources will also benefit the Latvian economy with increased employment and a more positive trade balance. If Latvia is going to continue its development and growth, it has do be efficient, not the least energy efficient.
The vision includes a phase-out of electricity imports from 2009, increased use of renewable energy, strong emphasis on energy efficiency, and reduction of natural gas after 2010.

Factor 4 for Energy Efficiency
In line with INFORSE's[1] global vision for sustainable energy, the Latvian Vision is based on increase of energy efficiency to reach an average level in 2050 similar to best available technologies today. A number of studies have shown that with best available technology, on the market or close to market introduction, it is possible to increase energy efficiency with a factor four or more for most energy uses. Most energy consuming equipments will be changed several times until 2050, and if new generations of equipment are made with optimal energy performance, and markets are made to promote the most efficient technology, it will not be a problem to reach today's best available technology, even though the efficiency gains achieved are very large, - in the order of 4 times, similar to an annual increase of efficiency of over 2% per year from 2010. This will not happen by itself, given that the "natural" technological development in EU countries has been about 1% per year. It will require concerted actions from stakeholders involved, but if it is done on EU-scale, and the market therefore is large for each new generation of efficient equipment, the changes will be cost-effective. The extra equipment costs will be off-set by energy savings. To realise this, it is, however, necessary to go beyond the conservatism of many market players in this field, and develop a truly enabling market for energy efficiency throughout the society. The factor four increase of efficiency is possible in Latvian electricity demand, except for construction and agricultural sectors that has very little electric intensity today, for road transport and for industrial heat and fuel demands.

The Challenge of Reducing Heat Consumption
For buildings the situation is different from equipment and vehicles because buildings often have lifetimes of 100 years or more. Many of the houses to be heated in 2050 are probably already built. Statistics indicates that efficiency of heating did not improve 2000 – 2005. On the other hand, the need for large replacement or major renovation of block houses build during the Soviet Union gives an opportunity for large increases in efficiency, if appropriate standards and support is in place. For Latvia, the proposed energy conservation targets for domestic sector should be realised as planned in 2016 and 2020 to reach final heat demand of respectively 195 kWh/m^2 and 150 kWh/m^2, and similar targets should be set for the service sector. In parallel, efforts to stop and reverse electric heating must be introduced rapidly. After 2020, efforts should be continued

[1] International Network for Sustainable Energy, see www.inforse.org

following EU regulation, leading to specific, final heat consumption of 82 kWh/m2 in 2050, or only 36% of the level in 2000. This is expected to be a combination of improved heating installations in houses and improved buildings.

It is also a challenge to reverse the current trend of increasing electric heating in Latvia for hot water and for rooms, a trend that goes again this visions proposal of strong energy efficiency. Electricity is the form of energy with the highest value and the highest environmental costs in production. It is therefore a pure waste to use electricity for heating. The vision does not include heat pumps in Latvia as they do not have an added value in the Latvian energy system; but heat pumps have been included in INFORSE vision for other countries with more intermittent electricity supply (mainly windpower). In Latvia the current trend in some places to replace wood-based heating with heat pumps goes again this vision. Instead we propose efficient and clean use of wood and in areas with more dense housing: extension of district heating.

Efficient Transport

For transport is assumed that the conversion-efficiency from fuel to transport-work is increased 2.5 times (from current 15- 20% in combustion engine systems to 50% in fuel cell systems with break-energy recoverage; direct electrically driven vehicles have even higher efficiency), and that the vehicles will be equipped with recoverage of break-energy, so the "end-use" of energy in transport is limited to the unavoidable friction losses in transport (except for aviation). This increase is expected to happen until 2050. Most of the changes are only expected after 2020, and the efficiency increase 2000 – 2020 is only expected to be 22%.

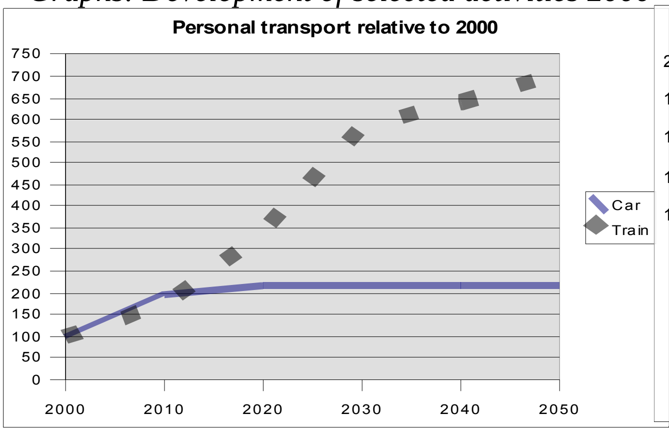
Growth Factors

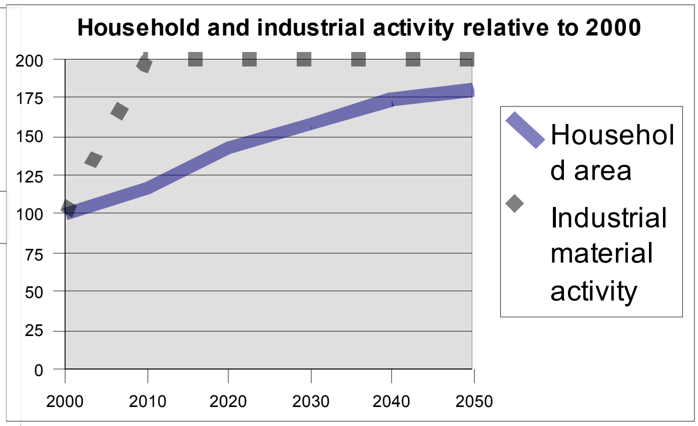
The growth of energy services, i.e. heated floor space, transported goods and people, energy consuming production, is expected to be rapid for 2-3 decades and then level off for most sectors towards the end of the 50-year period of the vision. This corresponds with present rapid growth and later approximation to the slower growth in the EU countries. The development is in general not "business as usual"; but will require policies to redirect economic development to less resource-demanding sectors and solutions, such as train transport instead of road transport for personal transport and stop of electric heating. The electricity demand follow Latvenergo's forecast for 2010, but is 7% lower in 2020 than extrapolation until 2020 of Latvenergo's forecast until 2016. Assumed growth in activities for Latvia are:

- Floor space, households: 2% annual increase from 2005 (6% in total 2000 – 2005), from 2030 only 0.5%/year, leading to 41 m^2/person in 2050;
- Floor space service sectors: 4.8% annual increase until 2015, then reduced to 2% until 2030 and then to 1% per year in the following decades.
- Electric appliances in households and service: 47% increase 2000 – 2010 following current trends, then 20% higher growth than growth in heated floorspace until 2030 and then growth following growth in heated floorspace. This will lead to an electric energy service level in 2050 of three times the 2000 level.
- Electric appliances in service sector: 68% increase 2000 – 2010 following current trends, then 20% higher growth than growth in heated floorspace until 2030 and then growth following growth in heated floorspace. This will lead to an energy service level for electricity-using equipment in 2050 of five times the 2000 level.
- Industry: growth of 49%/decade for processes demanding electricity and 66%/decade for processes demanding heat and fuels 2000 – 2010, following trends for 2000 – 2005; after 2010 no growth in physical production volume, i.e. no growth in drivers for energy demand;

assuming that increased value in Latvian industry will come from improved quality instead of increased quantity, following trends in Western Europe. The change of steel production in Liepāja from gas to electric arc heating technology is included with a change of 4.4 PJ of gas use to 3.6 PJ of electricity use in the steel sector before 2010 (assuming and efficiency increase of 20% with the change).
Personal transport: the vision includes a doubling of private car use 2000 – 2020, following current high growth. Then we expect a stabilisation on the 2020-level on 520 cars/1000 inhabitants equal to Western European (EU-15) level (current level in Latvia is 357 cars/1000 inhabitants). Bus use is expected to grow 43%/decade until 2020 following current trends and then 10%/decade until 2040 and then stabilise in 2040 on a level of 2.5 times the 2000-level. Train use is expected to grow 72%/decade following current trends until 2030 and then increase 10/decade reaching a level in 2050 of 7 times today's level. This follows a rapid decline of train use in the 90's when train use fell to 1/3 of the level in the early 1990's. As part of the increased train use, there are large opportunities to improve use of existing train lines in Riga[2] and many other places.
Freight transport: the vision includes an increase in freight train use of 4%/year until 2020 following current trends 2000 – 2006 and then increase 2%/year until 2040 and then remain stable on 3.3 times the 2000-level. Road freight is expected to quadrouble 2000 – 2010 following current trends and then grow 63% until 2020 and then remain stable remain stable on 6.6 times the 2000-level. Navigation and pipeline transport is expected to remain unchanged.

Graphs: Development of selected activities 2000





- 2050 for Latvia

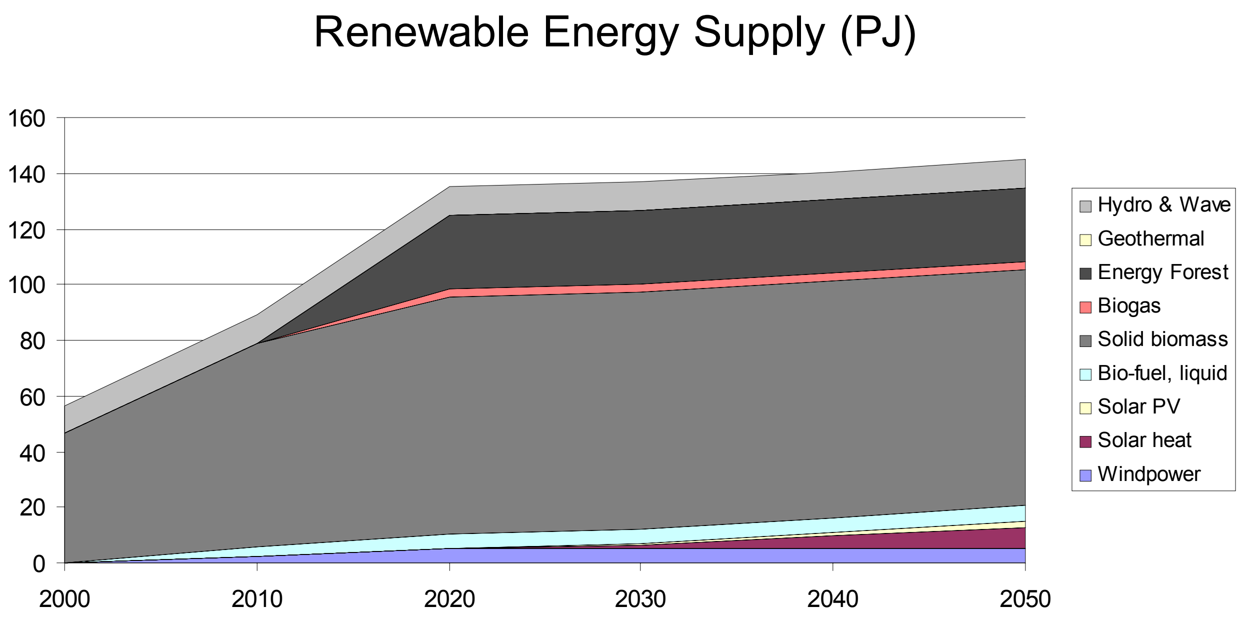
An underlining assumption for this development is a generally stable population in Latvia, with fluctuations below approx. 10%.

Renewable Energy

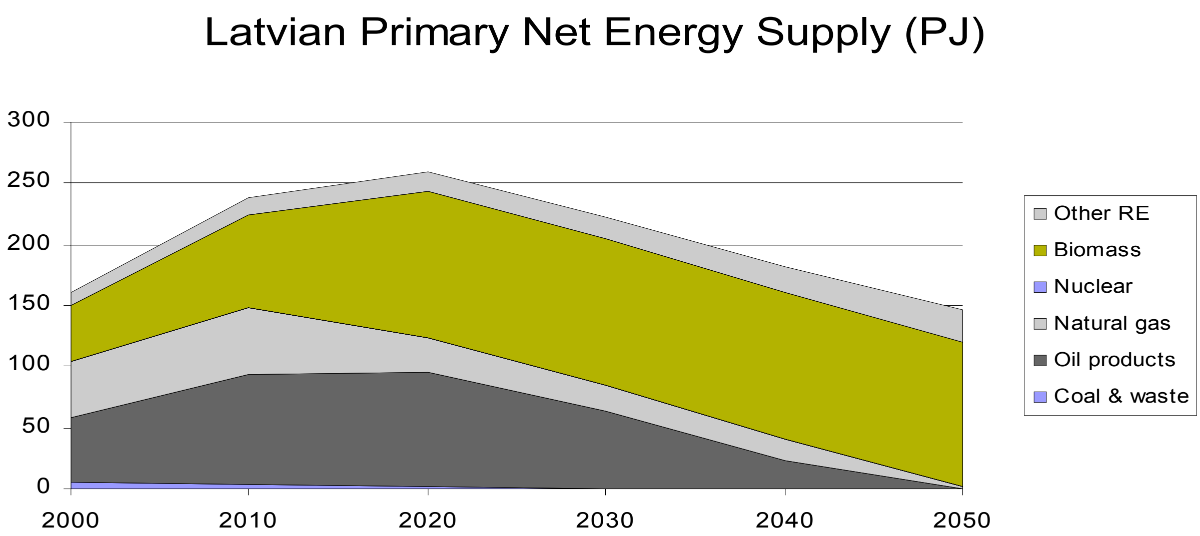
As a fraction of primary energy, renewable energy use is expected to grow from the 2000-level of 35% to 38% in 2010, to 51% in 2020, 60% in 2030, 77% in 2040 and 98% in 2050. For electricity the renewable share is above the share of primary energy, starting with 48% in 2000 and increasing to 82% in 2020 and 88% in 2040.

[2] In Riga only 3% of passenger transport is by train, much below EU average for cities.

The most important developments are in windpower and biomass including important use of agricultural land for biomass plantations, use of crops for biofuels and use of straw for heating and for combined heat and power (CHP) production. An important part of the straw is straw from liquid biofuel production from rape-seed. The use of agricultural land for energy plantations for solid biomass is expected to be 2200 km^2 until 2020, similar to 64% of the current area of non-used agricultural land. Also increase use of solar is including in the vision, while there is no increase in use of hydro-power, and geothermal is not included as the temperatures are low and the potential is uncertain.

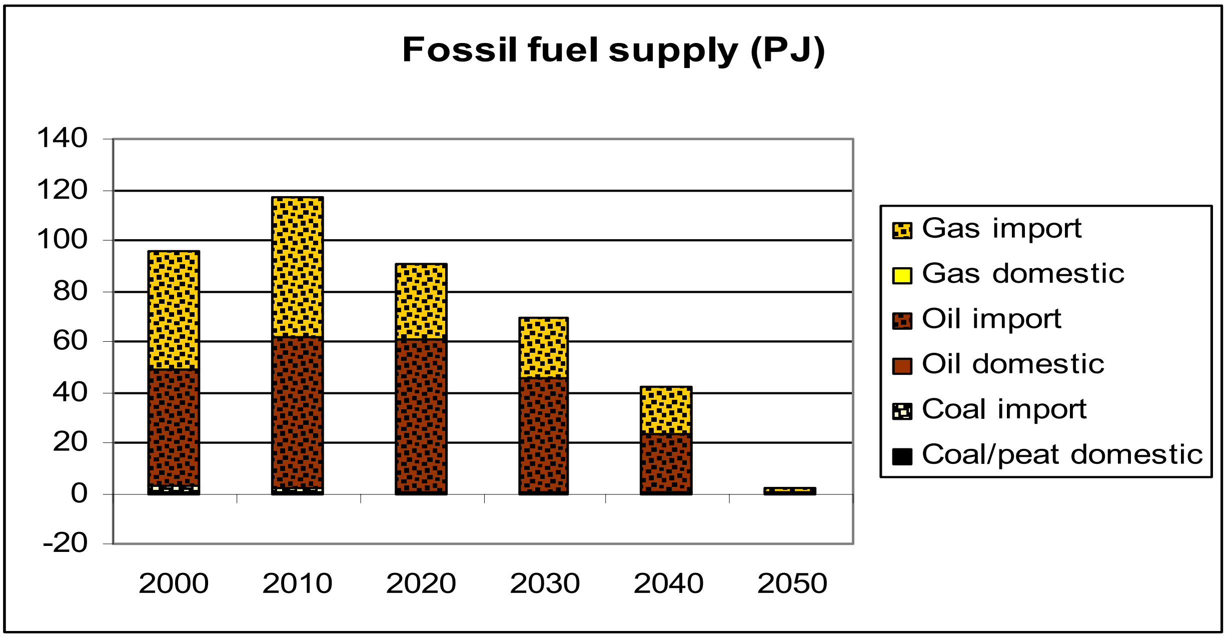


Graph: Increase in renewable energy supply, following this vision



Graph: Change in primary energy supply, following this vision. The decrease after 2020 is because assumptions of a less material growth than today and strong emphasis on energy efficiency.

Fossil Energy
Fossil fuel use is expected to grow until 2010 to cover electricity production and increasing heat and transport demands and then gradually be phased out until 2050.

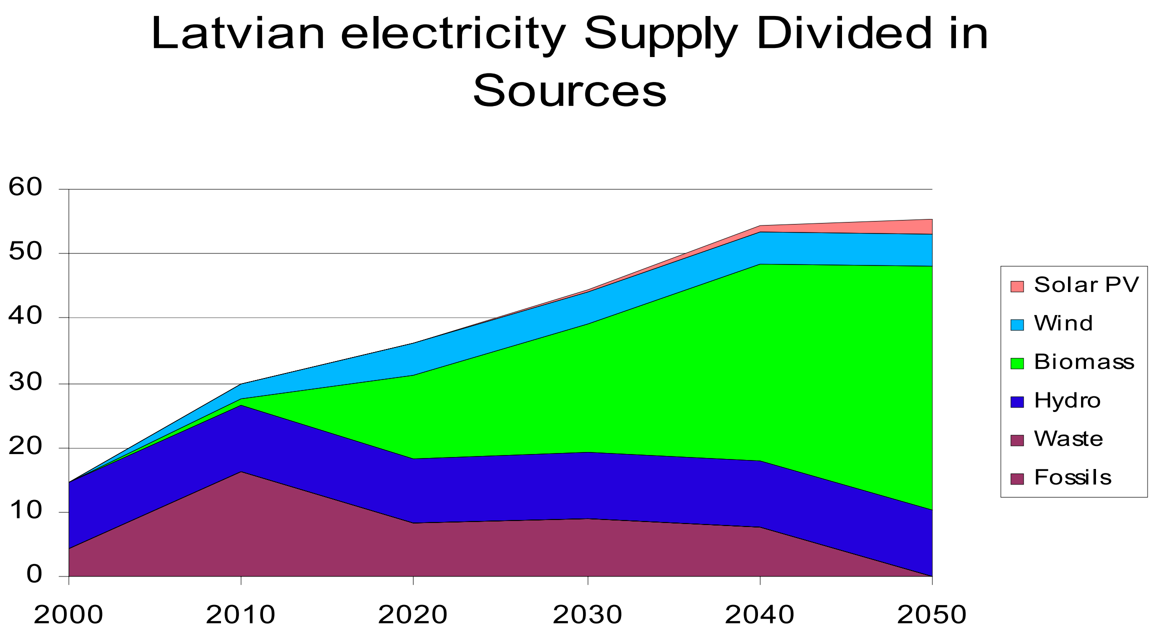


Graph: Fossil fuel supply Latvia according to Vision2050

Energy Conversion, Hydrogen
The energy conversion system will also have to be changed. The electric grid is likely to increase in importance, because electricity will also be used for transport, directly or via conversion to hydrogen. The increase in electricity demand and the change to biomass power will require construction of biomass CHP plants to produce 4 TWh (14 PJ) of electricity and 15 PJ heat. This will require construction of 800 – 1000 MW of biomass CHP plants until 2020.

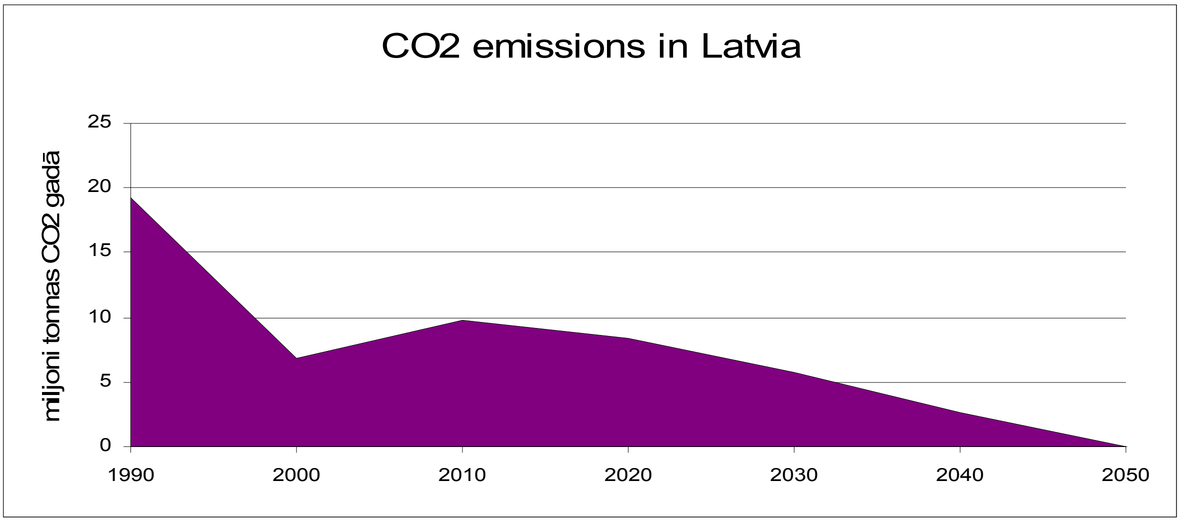
The increasing dependence on intermittent electricity supply from windpower and later solar PV can be managed with regulation on thermal and hydropower plants; but it might be necessary to construct heat storages in the form of hot water tanks to the CHP plants to decouple heat production and heat demand. With such storages CHP plants can better follow electricity demand. The intermittent electricity production from windpower will only be 15% of demand in 2020, according to the vision. It is not expected to increase relative to electricity production later. District heating will increase in importance, covering more than 40% of household and service sector heat demand from 2030 and more than 46% in 2050, an increase from today's 36% for household and 37% for service sector.

Gas networks are expected to have decreasing importance. They might play a role for transportation of hydrogen or biogas, but probably not for long-distance transport.



Graph: Development of electricity production and sources, following Vision2050

Energy Trade
Energy trade is expected to be much less than today, only a moderate electricity exchange is expected. Net electricity import is expected to be phased out until 2010 and then exchange with little net import or export is likely to continue in the following decades. If the efficiency assumptions are realised, there will be surplus electricity in 2050 for export.



Graph: Phase out of CO_2 emissions from energy

The above graph shows the CO_2 emissions from energy resulting from realisation of this vision. There will still be greenhouse gas emissions from other activities such as agriculture, probably including CO_2 emissions.

Actions for sustainable energy development for Latvia, until 2020

This is an overview of activities to realise the first steps for a transition to sustainable energy in Latvia, with main focus on the period until 2020. The purpose is the realisation of a Sustainable Energy Vision for Latvia with phase out of fossil fuels and net energy imports until 2050. The authors welcome comments.

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Windpower

It is proposed to install a total of 600 MW of windpower until 2020. The official plans are to install 298 MW of windpower until 2010. To realise the capacity of 600 MW, installations should continue with about 30 MW/year 2010 – 2020. This level is not high enough to attract windpower production to Latvia. Instead Latvia could look for regional cooperation to have one windpower production located in the Baltic States as well as the production in Latvia of components for windpower. With those two strategies, Latvia could benefit more from the employment in windpower.

When large parts of the first 298 MW of windpower are installed, it is important to clarify where the next 300 MW of windpower can be situated and is larger use of windpower than a total of 600 MW is feasible.

Requirements:
-Political decision to continue installations after 2010;
-Agreement for production of windpower components etc. in Latvia;
-Study on further use and potentials of windpower, from 300 MW to 600 MW and also above the 600 MW.

Economy:

- Installation of 300 MW windpower 2010-2020 will require an investment of 30 mill. €/year in the period 2010-2020 (30 MW/year, 1000 €/kW given a part if off-shore), in total 300 mill. €
- Energy Production: (0.75 TWh with 2500 full lead hours), replacing other electricity production.
- Operating and maintenance costs: expected 1 €-cent/kWh.
- Energy costs with 20 year lifetime and 5% interest and depreciation: 42 €/Mwh, equal to 0,029 Lat/KWh.

Even though the cost price of windpower without profit is an average of 0.29 Lat/kWh, it is necessary to pay investors a higher price for the first years, both as a risk premium and because of the bureaucratic obstacles that they have to overcome.

Biomass

Biomass is currently the most important form of renewable energy, and this will remain so until 2020, and also beyond. The current use of biomass is mainly wood used for room heating. 60% is used for domestic heating while 28% is for district heating, 10% is for heating in the service sectors, and the rest for industry and agriculture (2000 figures, IEA Energy Statistics).

Improve existing Biomass Use

An important first step is to introduce efficient use of biomass with clean and user-friendly combustion technologies and practices, to ensure continued popularity of wood use for heating. This requires training of those currently involved in biomass use (wood-stove producers and installers, chimney cleaners etc.) and introduction of clean, efficient and user-friendly technology. Given the size of the residential market (28 PJ = 8 TWh/year for heating), there is scope for a high-quality, Latvian equipment industry, adopting best available technology. Currently there is a lack of biomass heating equipment manufacturers on the European market, so it is possible that a good equipment production could also lead to exports, if the quality is high enough.

Requirements:

-Establish a centre of expertise of biomass use for heating (building on existing structures) with knowledge of Latvian, Baltic and European biomass markets: supplies, equipments etc;
-Free information to users about technology available (efficiency, environmental parameters, user-friendliness, suppliers, etc.) and good practices in biomass use such as appropriate drying and handling of wood, and firing;
-Training programme for current equipment manufacturers, installers, chimney cleaners etc;
-Labelling system for equipment;
-Promotion of high-quality biomass heating.

Economy:

-An expertise centre also in charge of web-based information will require about 5-10 full time staff;
-User information with outreach to biomass users including rural users will require 5-10 full time staff depending on level of ambitions;
-Training programmes will require 5-10 full time staff, and can be combined with above functions.

-Replacement of oil and gas with biomass for heating will save import of oil and gas. With replacement of about, 1.3 PJ of LPG use, 1 PJ of coal use, and 4.5 PJ of natural gas use, the fuel swift will save money for fuel import, money that are used instead to create employment in Latvia;
-Renewal of installations will increase efficiency from current 50-70% efficiency to 80% or more (annual average), increasing heat output with about 1/3. It is not known if this improvement will actually lead to less wood consumption or rather be used for better heating comfort (assuming some of the rural houses that use wood today are not heated fully to a satisfactory level such as 20'C).
-Renewal of installations will also reduce emissions, including particulate emissions from installation, thereby contributing to lower environmental costs and to the EU strategy to reduce particulate emissions.

Increase Biomass Use from Existing Wood Production
It is estimated that there is an unused potential of wood for energy of at least 10 PJ (2 mill. m^3). The sustainable use of this potential should be organised as a first step. This will by and large be done by the commercial sector; while the involvement of the district heating sector as a stable buyer could support the process and also help to establish a supply structure for biomass CHP.

Increase Biomass Availability with Energy Plantations and Straw Use
To make more biomass available for the proposed increases, straw and energy plantations should be used.

Regarding straw from grain is estimated an annual use of 375,000 tons/year for energy in 2020. The practical handling can be done by making the straw into large bales of 300 – 500 kg that is stored on the fields near roads and covered with strong plastic. Then they are sent by truck or eventually by train to CHP and heating stations during the heating season. This is normal practice in Denmark and other countries.

For straw from rape-seed is estimated an annual use of 650,000 tons/year in 2020. Existing practices exist in the Scandinavian practices for harvesting, collecting and transporting this straw to heating stations, where it is a useful fuel for heating of institutions, district heating networks etc. It's combustion properties are similar to straw from grain; but handling has to be adapted to this kind of straw that is more course than straw from grain and can give more ash.

For energy plantations (energy crops) is proposed that 2200 km^2 (220,000 ha), is planted with energy crops, partly unused agricultural area, partly about 6% of present agricultural area, including some pastures. There are a number of possible energy crops such as willow and elephant grass (*miscanthus*) for solid fuel and fast-growing grasses for biogas production. In this report as an example is used willow, but probably a combination of different energy plantations will be the optimal solution.

For energy plantations with fast growing willow, it is assumed that the yield will reach 7 ton of dry matter per hectare. The plantation and cutting can be done with machines, while there can be need for manual weeding the first year, depending on use of pesticides. The requirement for fertilisers is substantial less than for grain and most other crops; but there can be needs for fertiliser. Waste-water sludge can be used as fertilizer, if the sludge has low contents of heavy metals and persistent organic pollutants (POPs). Such substances can pollute the soil, which can be a problem for future use of the land for food production. If fertiliser requirements become substantial (because of poor soil), more permanent forests can be an alternative to short rotation crops. Use of pesticides is limited to the use of herbicides in the start and after each harvest every third year and it is possible to avoid the herbicides with manual weeding. Sweden and other countries have substantial experience with willow as an energy crop.

By 2020 the energy yield from energy plantations is expected to reach 35 PJ annually.

Requirements:
-expertise must be increased on energy crops and straw for energy use. Beside expertise on the technologies, experts should also evaluate how energy plantations are best integrated in Latvian agriculture: in larger areas, or smaller fields among existing farmlands;
-careful evaluation of the start of energy plantation investments is important, as energy plantations are only economically viable when biomass prices reach a certain level, coinciding with the full use of available wood residues;
-full-scale demonstration plants must be built, demonstrating energy plantation and straw use for district heating for one or two towns, engaging farmers and the municipality in the process;
-political decisions for the development should ensure a market so farmers can invest in machines and in conversion into energy plantations;
-for energy crops loans for farmers for transition is needed because there is no income the first 2-3 years with coppice;
-market – building with standard contracts and agreed price levels, to ensure the economy for farmers as well for the energy installations;
-use of EU Common Agricultural Policies to support energy plantations as much as possible. With the EU agricultural policy reform 2003 was introduced a support of 45 Eur/ha for farmers growing energy crops; this must also become available in Latvia. In some cases farmers can use set-aside land for energy crops and receive set-aside entitlements for the land with energy crops. (Source: http://ec.europa.eu/agriculture/markets/sfp/index_en.htm)

Economy:
-investment in straw balers and machines to plant and cut willow and other energy crops. Willov harvesting equipment for large-scale use is estimated to 100,000 -200,000 €;
-investment in energy plantations (work, time without income);
-annual work to bale the straw and cover it, to harvest energy plantation, and to transport to heating stations.

A Danish estimate is that energy plantation costs on sandy soil are:
-materials including establishment and herbicides: 100 €/ha annually;
-machine and wage costs including transport from field: 290€/ha annually.

Total 390 €/ha annually = 56€/ton dry matter = 3 €/GJ = 11 €/MWh. To this should be added land-use cost (rent of land); but the economy is 20% better on clay soil and with Latvian wages the wage costs will be lower. Thus, it seems reasonable to assume a price of 10€/MWh in Latvia for large-scale use.

Increased use of biomass for CHP and district heating, partly with energy plantations
With the plan is proposed to increase biomass use. The main increases until 2020 are in district heating stations and in CHP plants.

For CHP stations is proposed an increase in use of solid biomass from 1.28 PJ in 2005 to over 30 PJ in 2020, effectively creating a new power sector that provides 64% of the power from CHP plants (remaining 4% from biogas, 32% from gas and oil, no coal), resulting in power production of 18.2 PJ (5 TWh). Based on modelling of the energy system is found a need for construction of about 1150 MW-electric of CHP plants until 2020, including the current gas-fired CHP plant under construction in Riga that will have a capacity of 400 MWe. Based on current heat loads in Latvian district heating systems, this capacity could be distributed in the way described in the table below.

Possible expansion of CHP plants in Latvia, 2000 - 2020

Site	Heat load (GWh)	CHP nominal heat capacity* (MW-heat)	Electric efficiency	Electricity /heat ratio **	CHP nominal electric capacity (MW-electric)
Riga	4000	489	48%	1.50	733
Daugaupils	820	100	43%	1.16	123
Liepaja	655	80	42%	1.11	93
Ventspils	330	40	40%	1.00	42
Rezekne	245	30	40%	1.00	32
Smaller	1095	134	38%	0.90	127
Total					1150

* Nominal capacities are derived from heat capacities given in the background note from the vision, page 2 and 23, based on information from Latvijas Siltumuzņēmumu asociācija, AS „Rīgas siltums", AS „Latvenergo".
** On the assumption of a total efficiency of 80%, electric efficiencies from "*Technology Data for Electricity and Heat Generating Plants*"[3].
*** With this vision we only propose that just above half of the potential CHP capacity of smaller towns (250 MWh) is installed.

The electric capacities of the proposed power plants are considerably larger than the capacity of the existing gas-fired CHP stations. This is possible because of the higher electric efficiency of the new, state-of-the-art power plants and therefore a much higher electricity/heat ratio.

In addition to the CHP plants should be constructed heat storages in the form of hot water tanks to allow flexibility in heat delivery independent of power production, up to 26 hours of storage capacity can be beneficial in some cases.

For heating stations for district heating is proposed an increase in use of solid biomass from 10.85 PJ in 2005 to 23 PJ in 2020. The increase of biomass consumption for heating with 12 PJ will require installation of heating plants with of capacity of 750 MW-heat under the assumption of average use of 4000 hours/year. The use of 4000 hours/year (46% capacity factor) is an average for a few boilers used as main source in smaller district heating systems and boilers used as medium load together with biomass CHP plants and gas-fired boilers as peak plants.

[3] Report published by the Danish Energy Authority et.al. March 2005, ISBN: 87-7844-503-5 (available from www.ens.dk), data for solid biomass fired power plants, of 10 MW and 400 MW.

Requirements:
-feasibility studies for individual installations in existing district heating grids, also studying opportunities to combine existing heat loads from district heating, industry, etc;
-financing packages for installations;
-political decisions.

Economy:
The investment of biomass CHP varies between 1.3 mill. €/MW-electric for large plants (i.e. 400 MW-electric) to 2.5 – 3.5 mill €/MW for small plants (1-10 MW-electric)[4]. It is proposed that there will be 610 MW-electric of large plants with an investment of 900 mill € and 200 MW of smaller plants (including Ventspils and Rezekne) with an investment of 500 mill. € (2.5 mill. €/MW), total investments about 1400 mill. €.

In the table below (next page) is an overview of possible biomass power plants with indicative costs and technical parameters. The source for technical and economic parameters is "*Technology Data for Electricity and Heat Generating Plants*"[5]. Capacities are derived from heat demands and electricity/heat ratios of the proposed plants. Operating hour estimations are based on modelling of the Latvian energy system with hourly modelling with EnergyPlan[6] for 2020. Biomass fuel costs are assumed from market conditions and above estimate of 10€/MWh for energy plantations.

[4] These data and other data on biomass power plants are taken from the report "*Technology Data for Electricity and Heat Generating Plants*", published by the Danish Energy Authority et.al. March 2005, ISBN: 87-7844-503-5 (available from www.ens.dk), data for solid biomass fired power plants, of 10 MW and 400 MW. Another source for power plant costs is a report by Nuclear Energy Agency and international Atomic Energy Agency (IAEA) "*Projected Costs of Generating Electricity – 2005 update*", available from OECD bookshop; but that report has few relevant plants. It has only two biomass-powered CHP plants, of which only one is actually ordered: a 485 Mwe multifuel plant with stated investment costs of 1,13 mill. €/Mwe (2003 - €). A not realised 8 MW plants is quoted in that study to have investment costs of 3,25 mill €/MW. For a biomass plant without heat use, that study states a price of 1,49 mill €/Mwh for a 100 Mwe plant (2003-€) and based on a paper study 1,9 mill. €/MW for a 10 MWe plant with low efficiency. The same source gives for number of solid fuel plants (on coal) that are comparable with solid biomass-fired plants investments costs ranging from 1,06 – 1,19 mill €/Mwe for large coal-fired power plants, with the lower level of low-efficient plants (38-41% efficiency) and the higher end for a plant with higher efficiency: 46,3% efficiency for a 550 MW plant (coal boilers are cheaper than biomass bu flue gas cleaning more expensive).

[5] Report published by the Danish Energy Authority et.al., see previous note.

[6] EnergyPlan model, developed by Aalborg University, Institute, prof. Henrik Lund et.al.; modelling with 600 MW windpower and estimated energy demands for for 2020.

Possible Biomass Power plants		Riga	Daugaupils	Liepaja	Smaller plants
Specific invest. Costs	mill. € / MWe	1.3	2.12	2.18	2.5
Capacity installed	MWe	400	100	80	200
Total investment	mill. €	520	212.31	175	500
Lifetime	years	30	30	30	30***
LFCC	€/MWe	84567	138109	142112	162629
O&M-1	€/MWe/year	25000	59615	61923	70000
O&M-2	€/MWh	2.7	12.1	12.7	15
Eq.full load	hours/year	5606	5606	5606	4292
O&M costs	mill €/year	35.9	12.7	10.6	26.9
Eff-el	%	48	40	40	38
Eff-total	%	80	78	78	78
Fuel costs	€/MWh	10	10	9	6
Energy costs	€/MWh - total energy	26	37	37	41
Electricity costs*	€/MWh - electricity	33	49	48	56
Electricity costs*	LV/kWh	0.022	0.033	0.033	0.038
Heat costs*	LV/kWh	0.011	0.017	0.016	0.019
Electricity costs**	€/MWh - electricity	31	55	54	66
Electricity costs**	LV/kWh	0.021	0.038	0.037	0.045
Heat costs @E=.024 LV/kWh, in LV/kWh		0.008	0.027	0.026	0.032
Heat costs @E=.030 LV/kWh, in LV/kWh		-0.001	0.020	0.019	0.026
Heat costs @E=4,36 €cent/kWh in LV/kWh		0.000	0.021	0.020	0.027

* LFCC = Levelised fixed cost charge, the annual payment to pay back a loan with fixed annual. In this case it is a loan with 5% interest rate to be paid over 30 years.
** Electricity and heat costs on the assumption that the electricity price is the twice the heat price. The prices are "gate prices" and do not include distribution losses and distribution costs.
*** Only 20 year lifetimes for straw-fired stations.

In the last row in the table above is indicated a price of 0 for heat from the proposed CHP plant for Riga, this is not mistake, but it simply indicates that with the assumption used, the sale of electricity can pay for all costs of the plant.

The smaller CHP plants will be more expensive than the larger ones per produced energy unit; but we expect that they can have cheaper fuel because they are closer to the biomass resources. Even with the cheaper fuel assumed in the calculations, they will produce more expensive energy.

The cost of biomass boiler plants can be estimated to 200,000 €/MW-heat for plants above 2 MW, wood-fired and 20% more for straw-fired plants[7]. Installation of 750 MW, half wood-chip

[7] Based on REKA plant, 1.7 MW, wood-chip fired, hot-water or low pressure steam, including building and inlet/storage of wood-chips.

fired, half straw-fired will be 150 mill. €. Operating and maintenance is estimated to be 15,000 – 25,000 €/MW annually in Denmark. In Latvia wages are lower and O&M costs are therefore estimated to be 10,000 €/MW, leading to total O&M costs of 7.5 mill. €/year. The heat price from the plants is estimated to be 18€/MWh (gate cost without distribution losses), equal to 0.012 Lat/kWh with a fuel price of 10€/MWh. Some of this kind of investments have already taken place and is found to be cost-effective with wood residues as fuel. With the increasing gas and oil prices, also straw-fired heating stations are expected to be cost-effective today, even though they are 20% more expensive in investment than wood-fired stations.

Liquid biofuels

The proposal is to plant 180,000 ha (1800 km^2) with rape-seed by 2020 as part of Latvian agriculture. The rape-seed can be used for oil and the remaining press-cake that can be used as fodder. The straw can be used for energy (and be part of above-mentioned straw use for district heating and other energy purposes) or for agricultural purposes. The oil can be used directly in converted diesel engines or be made into biodiesel that either can be used directly or in a mixture with normal diesel. It is a political decision if the use should focus on use of pure plants oil, on biodiesel, or of blending biodiesel with normal diesel.

Alternatively can be produced other kinds of biofuels, such as grain-based ethanol or second-generation biofuels.

The strategy will depend on the choice of biofuels. Here is proposed a dual strategy with pure plant oil/ethanol for rural use and blending into diesel and petrol of respectively biodiesel and ethanol. Currently the official policy has most focus on blending.

Requirements:

-building a knowledge base and a practical advice service on environmentally benign growth of rape seed and other biofuel crops, with minimal use of fertiliser and pesticides in Latvian circumstances, optimal use of all products from the cultivations;

-practical advice and training in use of pure plants oil, motor conversions, production of biodiesel and blending with fossil diesel;

-political decisions to exclude pure plant oil from excise tax under certain conditions (such as local use, small-scale production etc.).

Economy:

While rape seed is already grown in Latvia, there will be need for additional investment in machinery for harvest. There will be need for investments in oil press and storage facilities for the oil. This can be decentralised at farm/village levels or it can be centralised. If ethanol production is chosen, there will be need for investment in ethanol production facilities.

Conversion of vehicles to run on pure plant oil is about 1000 €/vehicle. If the average vehicle runs 10,000 km/year, has a fuel efficiency of 10 km/l and operates for 10 years, its consumption is 10,000 l (10 m^3) of fuel, and the conversion costs 100 €/ m^3 of fuel (10 €-cent/l). Some commercial vehicles have substantial higher use than 10,000 km/year and therefore lower conversion costs per l of fuel used.

Conversion of plant oil into biodiesel for blending in ordinary diesel can be done centrally or at village level. The costs are moderate.

Biogas
The estimated gas production from biogas plants is 3 PJ in 2020 and later. We propose that the plants are to be constructed in the period 2010 – 2020.
The production of 3 PJ of energy as gas can supply 40 MW-electric of CHP plants, with the assumptions of 8000 operating hours/year and 39% electric efficiency. The net energy output is 2.7 PJ (heat +electricity) as the own consumption for heating of the plants is 10% of the heating value of the gas produced (process heat). Alternatively some of the biogas can be used in transportation, as is increasingly done on Sweden.

Requirements:
Since there is very little previous experience with biogas from agricultural materials, there is a need to try the technology with a number of demonstration plants and
There is a need to build capacity to operate and maintain biogas plants with training etc.
A political decision to use landfill gas for energy should be part of the climate plan (currently the gas is just collected).
Support for construction of biogas plants should be introduced, including preferential loans.

Economy:
The investment in biogas can be estimated to about 5 mill. €/MW-electric, or a total investment of 200 mill. €. This is for agricultural plants of capacity of 1 MW electric (medium-large plants). Other plant sizes will have different prices e.g. a plant with a capacity of 3 MW- will have an investment cost of 3 mill. €/MW. Landfill gas plants have lower investment per MW than biogas plants.

With investment of 5 mill. €/MW-electric, 20 years lifetime, 8000 operating hours/year, 5% interest rate, the investments cost per MWh-electric are 50 €, equal to 25€/MWh total energy. Operating and maintenance costs are estimated to 30 €/MWh-electric equal to 15 €/MWh total energy for Denmark; but this figure can be lower for Latvia.

Total costs can then be estimated to 25+15 = 40 €/MWh of total energy delivered; but can be lower for Latvia, and will depend on plant size. An assumption for this is that manure and waste is delivered for free at the biogas plant, and the produced sludge is taken away for free by farmers that can use it as fertiliser.

If the power is sold to the grid for 0.06 Lat/kWh (current feed-in tariff up to 4 MWe), the remaining cost (expenses minus income from sale of electricity) is only 0,005 €/kWh for the heat. Thus, if the biogas plant can sell the heat for more than 0.005 €/kWh (5 €/Mwh), the investments will be profitable on the above conditions.

Hydropower and Geothermal
There is no expansion planned of hydropower and geothermal energy use, so no additional actions are expected.

Solar Energy
There is no market for solar energy installations in Latvia for the moment. This is expected to change after 2010; with the development of solar heating expected to start and result in average installations of 10,000 m^2/year 2010 - 2020 (total 110,000 m^2 installed in 2020).

Requirements:
-Demonstration program for solar energy;
-Support scheme for solar heating in selected applications.

Economy:
-Installation of solar heating will require investments of (2 mill. €/year (200 Eur/m2));
-Energy Production: 48 GWh/year in 2020, replacing heat from gas with an efficiency of 80%, leading to gas consumption reduction of 60 GWh/year.

Heating efficiency

It is proposed that a 33% reduction of specific heat use in residential buildings will be implemented until 2020 (realisations of proposals from Statement of Energy Supply). Similar reduction is proposed for the service sector. This will require investment in a number of heat conversation measures such as improvements of building envelops (roofs, windows, floors, walls) and of heating systems (insulation and renovation of heat pipes, better regulation). These measures will in general be economically beneficial. With the increasing fuel prices, an increasing number of advanced measures will become cost-effective, such as more insulation and advanced regulation.

After 2020 is proposed a long-term effort leading to reductions in specific heat demand of 2%/year. This will require further improvements of building codes, continued information on energy efficiency, and in general an ambitious implementation of the EU “buildings directive” on energy efficiency in buildings.

Heat pumps are not included in this vision as they do not increase overall efficiency and they increase electricity consumption, which goes against the aim of reducing electricity import to Latvia.

To realise the heat demand reductions is needed:
-a strong program for heating efficiency with free public advice and training of building companies, building managers, municipal building authorities and others;
-subsidies for low-income households to increase efficiency;
-use of EU funds to increase energy efficiency of public buildings;
-promotion of loans for energy efficiency including development of low-interest loans, and state guarantees when appropriate;
-gradual increase of building standards for new buildings to reach Western European levels;
-an national energy efficiency program with regular update, including some of the above proposals and financed from a small levy on fossil fuel use for heating.

Energy efficiency in Electricity

For energy efficiency in electricity use is proposed an increase of 2%/year. To realise that is proposed:
-immediate stop of installation of electric heating, including installation of electric water heaters as the prime source of hot water heating. Electric heating increases the waste of the overall energy system and goes against the realisation of this vision;
-a levy of 2% of electricity consumption to be used to improve electricity efficiency with information and subsidies;
-information campaigns on the savings possible with energy efficiency in electricity use for all sectors including the residential sector. As part of that should be specific campaigns for the

different industry and service sectors. The campaigns should use existing EU labelling schemes, but also include equipment that is not yet covered by labelling;
-a special campaign to replace electric heating with other forms of heating.
-targeted subsidies for purchase of the most efficient equipment, for avoiding inefficient equipment, and for replacing electric heating with other forms of heating.

The proposed measures are expected to be cost-effective, including the payment of the 2% levy. Regular evaluations should monitor the cost-effectiveness of the schemes to ensure the maximum benefits for the users and for the environment.

Energy efficiency in Industry and Private Service

While private sectors are covered by above-mentioned activities for space heating and electricity, there is a need for additional actions to improve energy efficiency in the commercial sectors. The above-mentioned sector specific information campaigns for electric efficiency can be expanded to cover all types of energy. In addition can be introduced energy taxes, voluntary agreements of implementation of all cost-effective measures, special financing etc.

Energy Efficiency in Public Service

The public sectors are covered by above-mentioned activities for space-heating and electricity; but also for the public sectors special additional actions will be beneficial. Public institutions should carry out all energy efficiency measures with simple pay-back periods below 6-10 years. To enable this, funding must be available for the investments. As an incentive, public institutions should be able to keep a part of the economic savings from energy efficiency measures for the first years after the investment.

Further, institutions should always purchase equipment with the highest efficiency, or at least the highest cost-effective efficiency. If the energy efficiency equipment is more expensive, the investment budgets must be increased with the cost-effective part of the extra cost.

Energy efficiency in Transport

It is proposed that energy efficiency for cars is increased 1.5%/year 2010-2020, increasing to 3%/year 2020-2030. It is recognised that can be difficult for personal cars due to the large import of inefficient used cars. Thus, it is important to address the energy efficiency of imported cars.

Energy efficiency in transport can be increased in a number of ways:
-taxation for car use and for car registration/import shall be graduated according to energy consumption;
-public transport companies shall have incentives to increase energy efficiency, e.g. by a levy of their fuel use that is recycled to energy efficiency improvements in public transport. It is important that such a levy is set on a level where it will not harm public transport compared with individual transport;
-tax incentives to use public transport to and from work, and to use bicycling;
-eventually tax penalties for long-distance commuting;
-campaigns on real cost of buying inefficient cars, such as old, imported cars.

In addition, urban and national planning should minimise transport needs and favour rail transport and bicycling over motorised road transport, in particular personal cars.

Background note

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.

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 the 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 vision 2050 (chapter 5).
Finally 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)

National economic strategy in the period up to 2010 projects GDP increase by 8% annually, but in the long term (until 2030) 5% annually. 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[8] 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.

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1. 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:

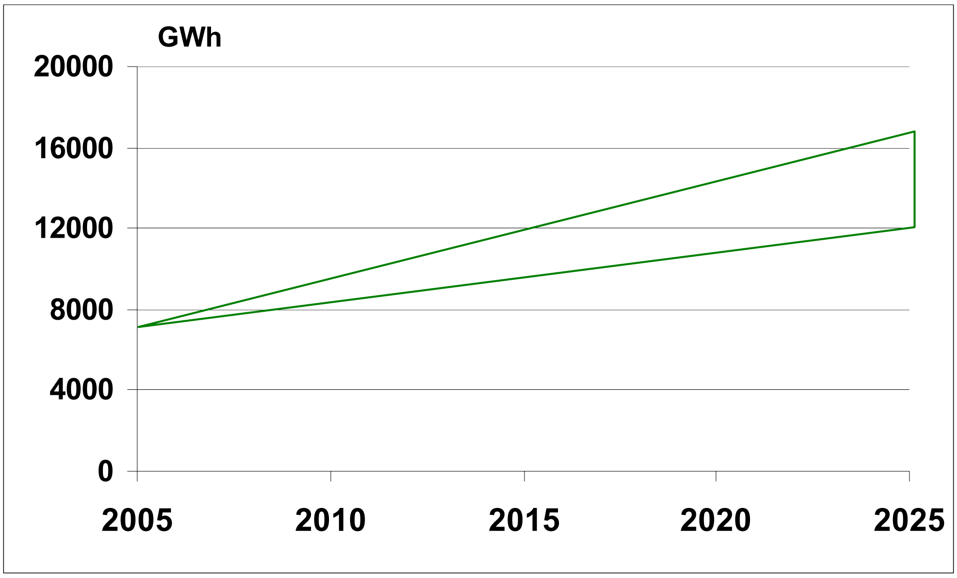
	Ķegums HPP1/HPP2	Pļaviņas HPP	Riga HPP
Installed capacity, MW	72/192	868,5	402
Number of hydro aggregates	4/3	10	6
Maximum head, m	14/14	40	18
Dam length, m	2161	4032	15400
Multiple annual average flow , m^3/s	615	610	640
Water reservoir capacity, million m^3	168,3	500,1	324,6
Estimated minimum energy storage capacity (GWh)[9]	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 reserve fuel for boilers)	Natural gas (heavy fuel oil as reserve fuel)

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

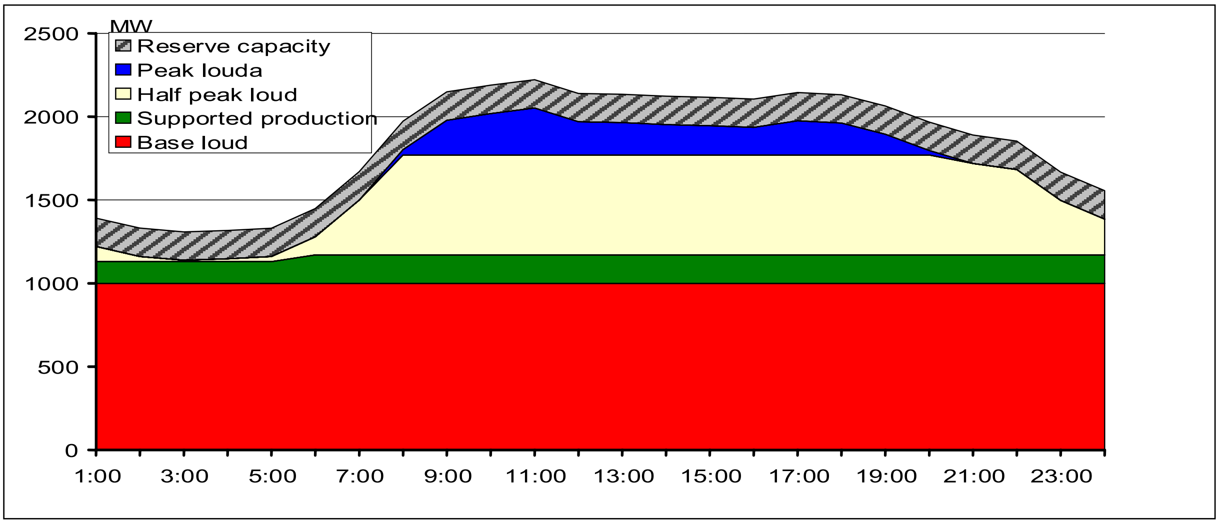
Scenario for electricity demand from Latvia's Investment and Development Agency's study on the base load, 2007:



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

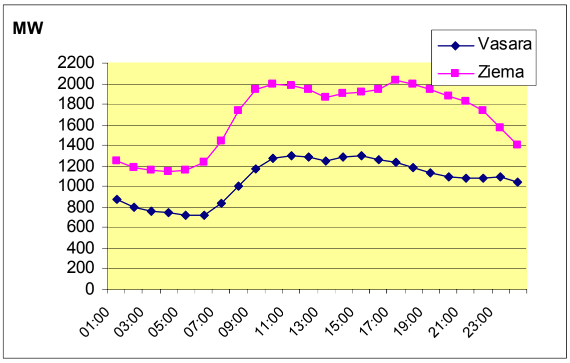
Year	Annual consumption (bruto)	Peak load
	GWh	MW
2005	7051	1272
2006	7482	1420
2007	7689	1474
2008	8068	1531
2009	8463	1589
2010	8610	1650
2011	9031	1715
2012	9342	1782
2013	9794	1852
2014	10264	1925
2015	10614	2000
2016	10779	2057

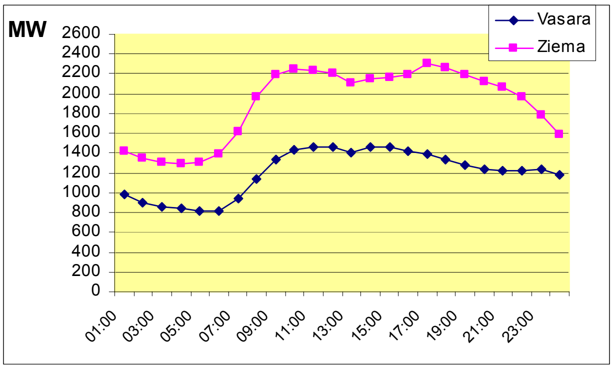
Report from Transmission system operator, scenario for year 2016:

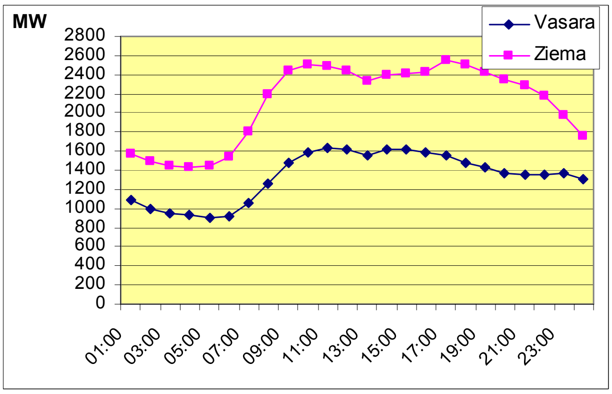


Type	Supported production	Base load	Half peak load	Peak load	Reserve capacity	Imported power
Power, MW	200	1000	600	300	150-250	+- 400
Use, hours a year	>6000	>6000	<3500	<1000	8760	

Max electricity demand (2015, 2020, 2025) (Vasara – summer; Ziema – winter)[10]

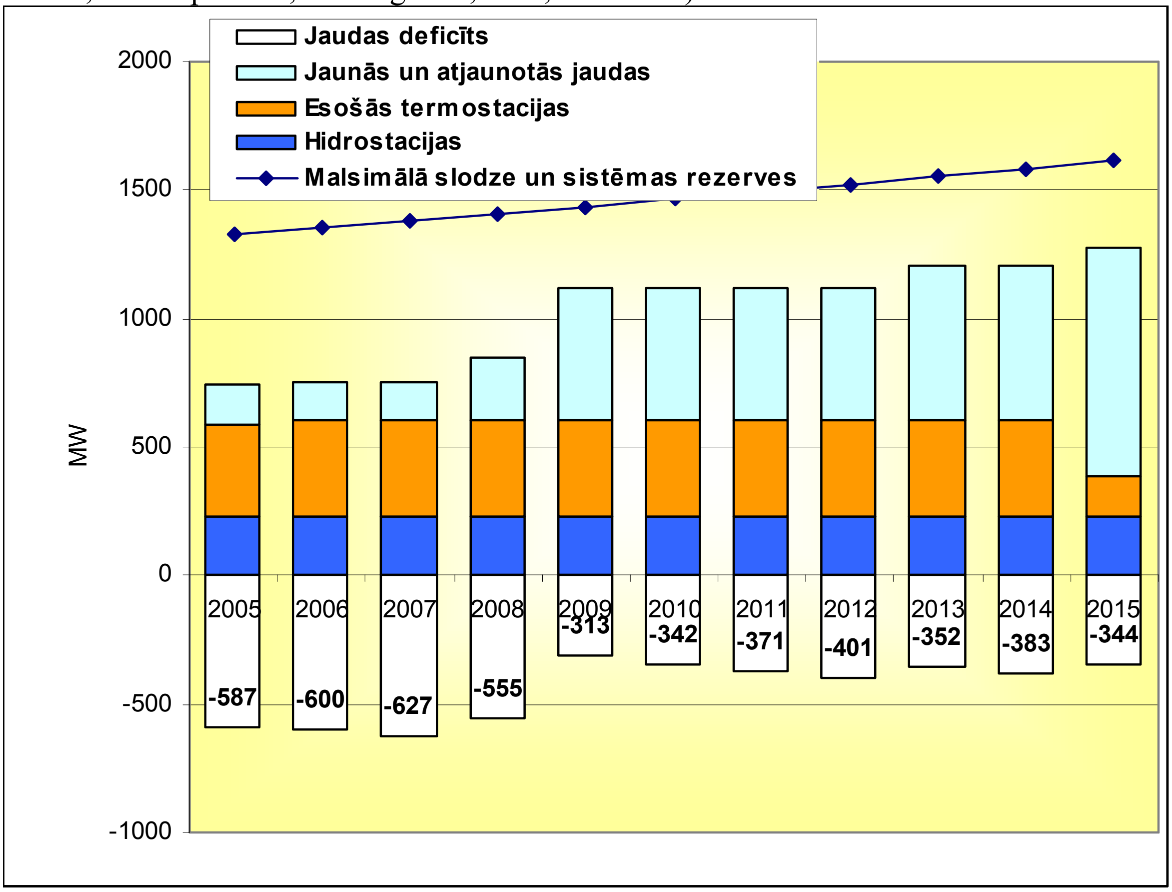






[10] Latvian investment and development agency.

Possible electricity demand in the December when there is 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 planed 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 capacity 400 MW in Kurzeme region (Western Latvia at the Baltic Coast).

Development of heat and primary energy demand for heat and processes (PJ, (TWh))[11]

	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)

[11] 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	Vecmilgrāvis	Imanta	Ziepniekkalns	Daugavgrīva
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

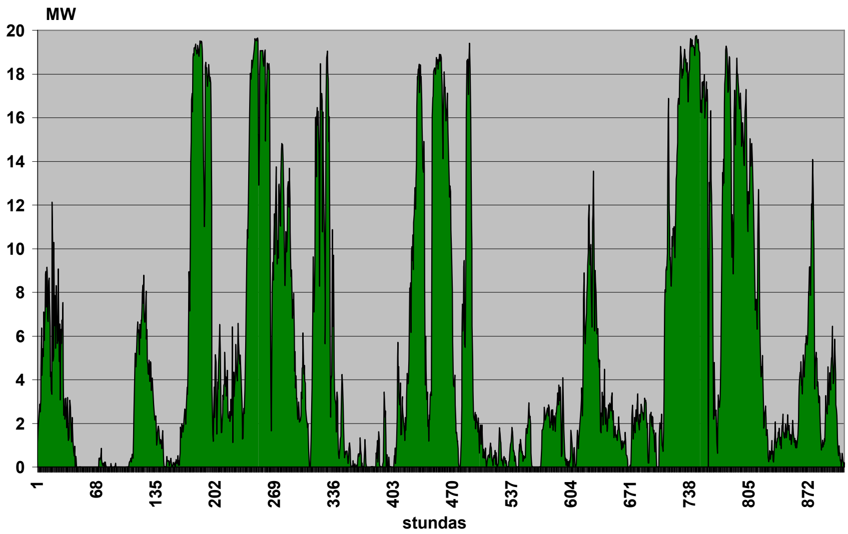
2. Renewable Energy Potentials

Windpower
Officially 132 MW (298 GWst) of windpower (with capacity factor of 2300 full-load hours per year), are to be installed by 2010.

According to the assessment of Latvijas Wind Energy Association totally it is possible to install around 600MW of windpower.

According to the data from the EBRD Renewable Energy Program the practical windpower potential is estimated at 1,000 GWh/year and it represents about 2,000 MW of wind power capacity; but there are some uncertainties about this potential.[12]

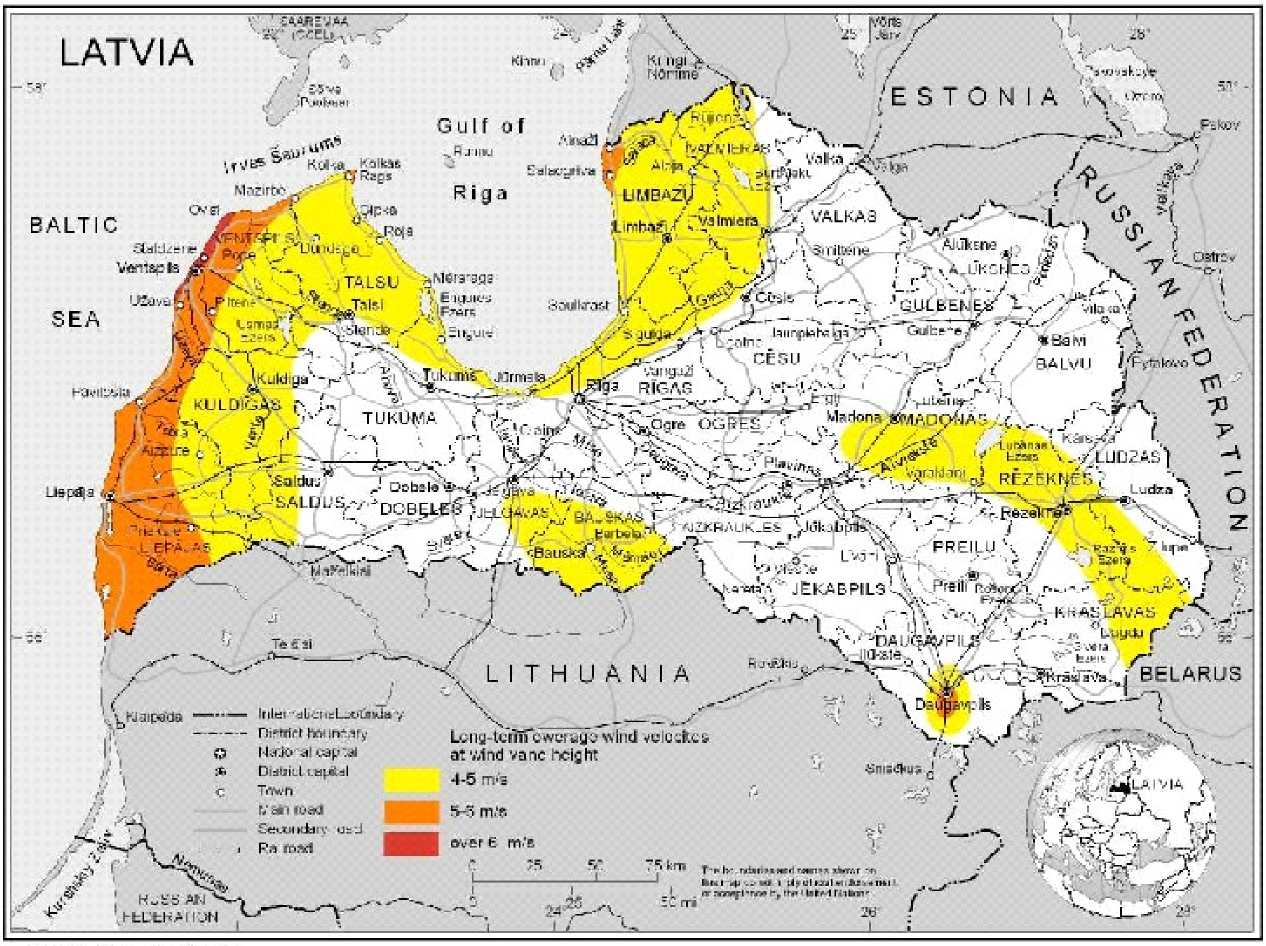
Variation in windpower production as measured in Latvia (stundas = hours), probably 2005.



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 off-shore 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.

[12] http://ebrdrenewables.com/sites/renew/countries/Latvia/profile.aspx



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Historical windpower production:

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

Currently Latvia has 7 enterprises with 41 wind turbines installed with a combined capacity of 135 MW (2006).

For this study is used a potential of 600 MW with 2500 equivalent full-load hours. Presently the figure is about 2300 hours. The higher number of full-load hours is based on the assumption that the developments are partly offshore.

300 MW will be utilized by 2010 and the full potential of 600 MW by 2020.

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. A largest existing solar heating project is at the Aizkraukla School[13] 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, e.g. 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 for 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)

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

[13] www.gimnazija.aizkraukle.lv

The installed area for solar electric generation (PV) is expected to follow take off as 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 mill m^2 will be used for solar heating and 5.8 mill. m^2 will be used for solar electric generation, in total about 11 mill. 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 roofs. 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.

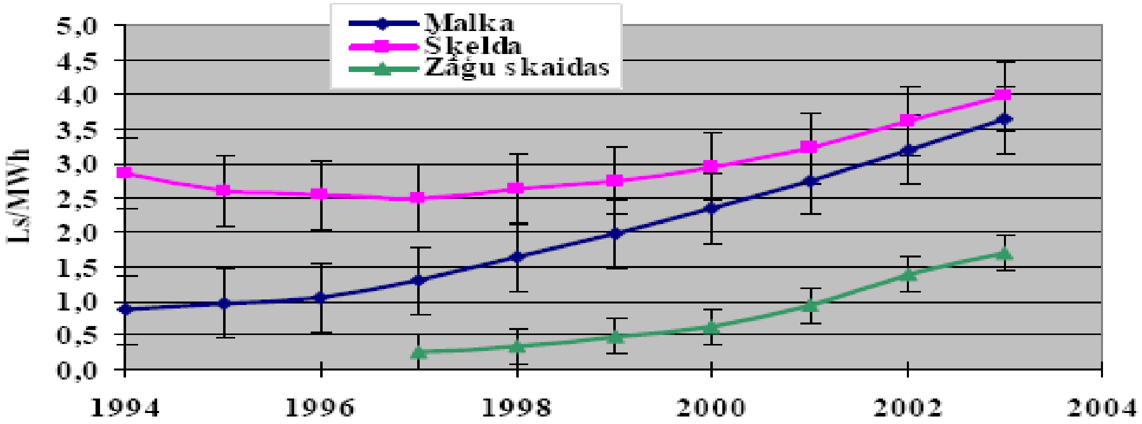
Wood is already used to a large extent today, mainly for heating in the domestic and service sectors and in district heating. It is predominantly waste from the timber production. It includes firewood, wood pellets, briquettes and wood chips. Production and consumption of wood for energy increased considerably 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[14], of 44.5 – 82.5 PJ.

In 2005 Latvia exported total of 24.3 PJ[15] of wood for energy. Export of wood for energy in 2005 has a slight increase of 7.3% by volume and 21.3% by value. Thus it should be concluded that the increase of export volume was not caused by price increase, but by the increased share of the more expensive products – pellets and briquettes. In 2005 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. Out of that 284 100 tons was firewood with annual increase by 9%; 2.48 million tons of woodchips with increase by 63.3%; but export of wood wastes was 514 200 tons, a slight decrease compared with 2005[16]. Over the same period also import of wood for energy increased – by 96% from 19500 tons to 38400 tons (firewood import decreased by 49.1%; woodchips increase by 88.4%; but import of wood wastes increased by 161.5%).

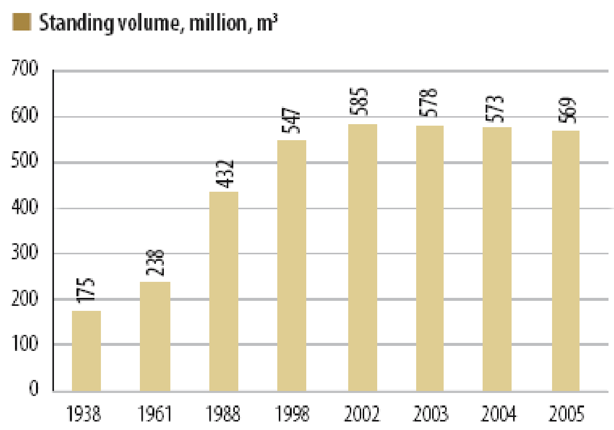
Export price for woodchips in year 2006 was in the range of 5-6 LVL/m^3. (7.3 – 8.7 LVL/MWh equal to 10-12 Eur/MWh with the assumptions of density 235 kg/m^3, energy content 2,92 MWh/ton, 1 Eur = 0.702 LVL). Price for sawdust brick fuel can reach (8.2-8.8 LVL/MWh)[17].

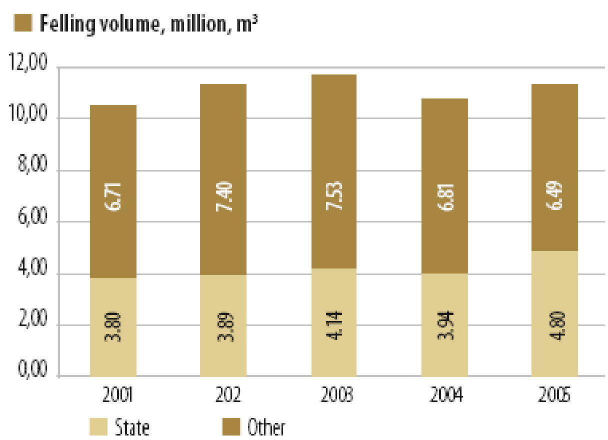
[14] Atjaunojamo energoresursu izmantošanas pamatnostādnes 2006.– 2010. gadam
[15] Central statistics office.
[16] Ministry of Agriculture, http://www.zm.gov.lv/doc_upl/2005_2006.pdf
[17] 1 LVL = 0,702 EUR

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 m^3. At the beginning of 2004 total forest stock was 578 milj. m^3. During 2004 10.75 milj. m^3 were cut, which makes 66% of the growth[18]. Developing 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 baste on field trials there are 3313 thousand ha of forest with total standing volume of 629 mill. m^3. They estimate:

- the annual increase in the forest volume at 25,53 mill. m^3 annually,
- 60,42 mill. m^3 of dead wood and 52,04 mill. 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 mill. m^3 of fuel (technical potential is around 4 mill. m^3). According to data from Latvia's environmental agency, currently around 2 mill. 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 remains around 1-1,5 m^3 loose wood residues. Analysis of Ministry of Agriculture on biomass resources available in Latvia shows that currently approximately 5 mill. 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

[18] State forest service.

wood fuel from Latvia after the study was launched (export increased 950,000 tons from 2005 to 2006, equivalent to about 1.2 mill. m^3), we only include 2 mill. m^3 of the above-mentioned 5 mill. m^3 as additional potential use of wood fuel for existing sources for energy in Latvia. This is equivalent to a potential increase of use of wood fuel form existing sources with 10 PJ.

For this study is used a future production of wood for energy of 94 PJ, equal to the production in 2005 + the above-mentioned additional potential of 10 PJ. Further increase in the use of wood for energy is expected to come from new plantations of trees, as described below under "energy plantation".

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 t. It has 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 rape-seed will lead to increased production of rape-seed straw. The production of one ton of rape-seed oil, roughly equivalent to one ton of biodiesel, will give 3.9 ton of rape-seed straw with an energy content of 14.5 GJ/ton[19]. The production of 168,000 ton of rape-seed 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 rape-seed oil (see below). Straw from rape-seed is less used internationally than straw from grain. Not all equipment for straw firing can be used for rape-seed straw, but technology for its use as fuel is available.
Also the press-cake from the rape-seed can be used for fuel with an energy potential of about 5 PJ for the 168,000 ton of rape-seed oil; but it is also valuable as fodder and is therefore not included as an energy source in this study.

According to report on energy from Physical energy institute[20] the potential from straw for 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 rape-seed 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).

With this we use a total solid biomass potential is 109 PJ, combining the 94 PJ of wood and 15 PJ of straw including rape-seed straw. Of this 84 PJ is used today

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

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

(2005), the remaining potential for wood is expected to be used in 2010 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 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)[21].

The maximum rape seed plantations are 180,000 ha according to Latvian Renewable Energy Statement[22]. This will provide 168,000 t of biodiesel, equal to 6 PJ, as well as straw and press-cake. The present area with rape-seed 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 rape-seed, 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 is assumed 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 mill. ton of manure.
- 0.4 mill ton on biodegradable household waste;
- 0.034 mill. ton of animal waste;
- 0.18 mill. 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 mill. m^3 of biogas from manure;
- 23 mill. m^3 of biogas from biodegradable household waste;
- 23 mill. m^3 of biogas from food production and processing waste;
- 16.8 mill. m^3 of biogas from green mass (leaves etc.);
- 10.8 mill. m^3 of biogas from active sludge from waste water plants;
- 10.65 mill. m^3 of biogas from animal waste.

From this amount it is estimated that the production can be 290 mill. m^3 biogas or 5 PJ energy and fertilizer for agriculture.[23] In the Biogas strategy[24] it is estimated to have 174 mill. m^3 biogas annually or 3 PJ energy.

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

In addition to this biogas potential, there is a potential of landfill gas which is not evaluated in this study.

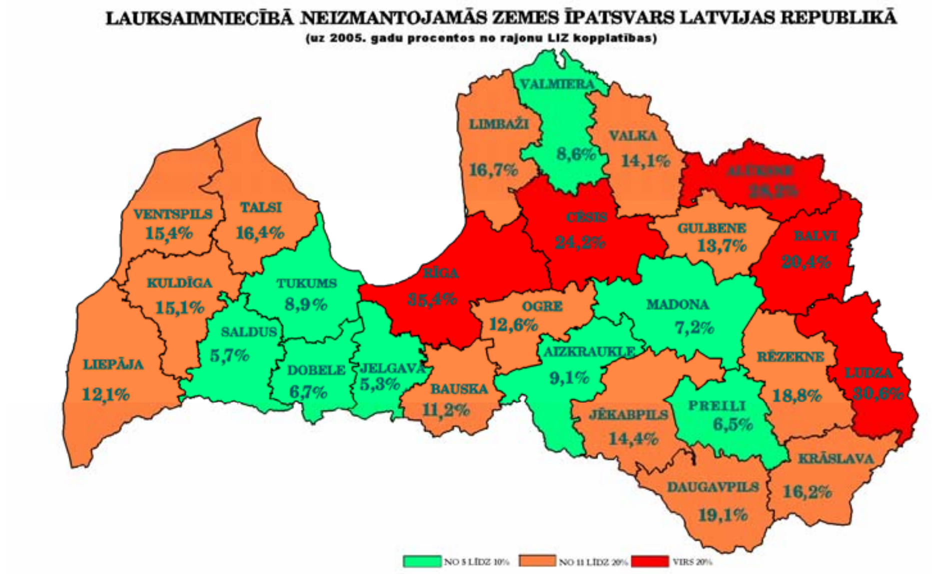
Currently total installed capacity of biogas in Latvia is 7.786 MWe which is producing electricity and heat from gas from landfills and sewage sludge.

We expect a large development of biogas, resulting in the full technical potential of 3 PJ utilised by 2020.

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[25]. 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:



In 2005 in Latvia there were 30-50 ha of willow (salix) plantations[26]. Most of them are eliminated by now, because there are no agricultural support (area payment) for this, but it is expected that such payments could be introduced starting from 2008, 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 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.

[25] Assessment done in 2005 by „ Latvian Rural Consulting and Education Centre".
[26] http://www.zm.gov.lv/doc_upl/Iscirtmeta_energetiskas_koksnes_plantaciju..._Silava.pdf

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[27] 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).

We expect the development of energy plantation to take off after 2010 and that 64% of the area is utilised by 2020 and later.

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 temperature are in the range of only 25-30'C[28] 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.

Hydropower

Production of large hydropower was in 2790 GWh in 2005 and of small hydro-power 58 GWh (3100 h/ year). The potential for additional hydropower is not assumed to be acceptable for environmental reasons. Therefore we have not included expansion of the hydropower capacity.

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[27] 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.
[28] EBRD, Country report 2005.

3. Efficiency Potentials

For the vision is used 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 (10% for road freight, passenger cars, industrial energy consumption, and domestic and service electricity use)
- 2010-2020: 2%/year (1.5 % for road freight, industry, domestic and service electricity use)
- 2020-2030: 3%/year
- 2030-2040: 4%/year
- 2040-2050: 4.4%/year

The higher expected increases in efficiency 2000 – 2010 for road freight, domestic and service electricity use is because of ongoing rapid replacement of appliances and vehicles.

- In the transport sector the realisation of the efficiency will require a technological shift from present internal combustion engines with 15-20% efficiency to hydrogen fuel cells with >60% efficiency and electric vehicles with about 80% efficiency, including battery charging cycle losses. In addition is expected implementation of technologies to regain brake-energy from vehicles.

The expected increase in efficiencies will only happen with working energy efficiency policies in place from 2010.

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. Also for these sectors the start is expected to be slow: 5% increase 2000 – 2010 for agriculture and construction and no increase in efficiency in rail transport and navigation in this decade.

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))[29]:

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[30]. In Latvia study on potential developments in manufacturing industry until 2020 was done by SIA Baltijas Konsultācijas 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 is assumed 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.

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.

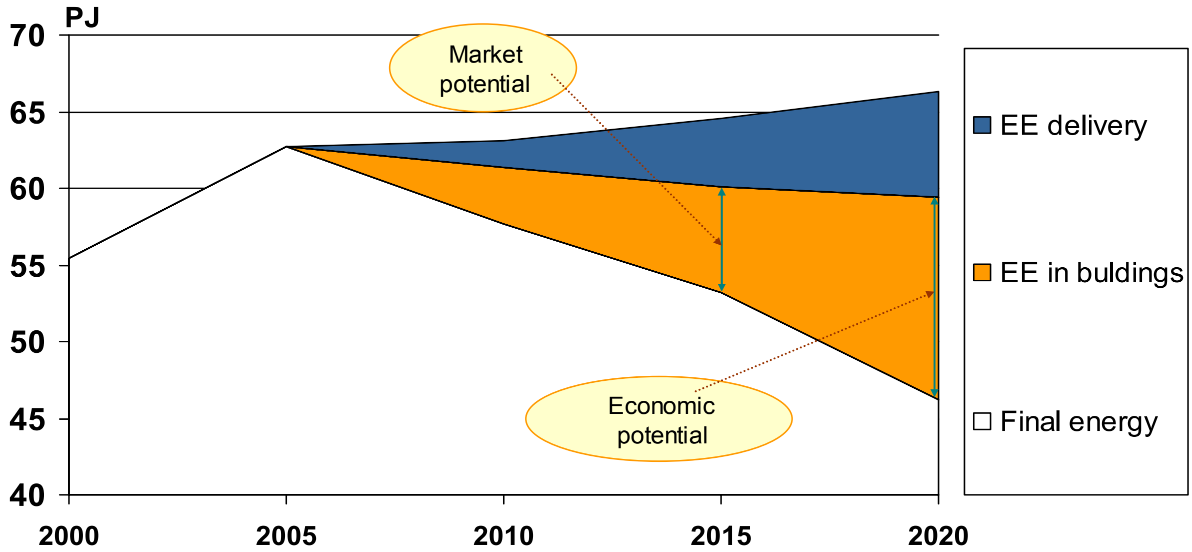
In Latvia there is very low energy efficiency in buildings. I Riga final energy demand for heating (including internal losses in buildings) is assessed to be on average 231 kWh/m^2/year, and in the rest of the country 220-250 kWh/m^2/year[31]. Also the heat losses in the district heating networks are 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.

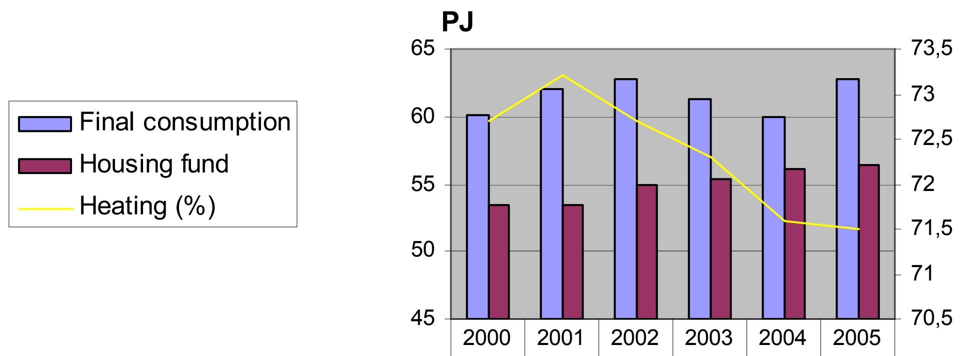
By realizing market potential and decreasing energy consumption to 195 kWh/m^2/year it is possible to save 7 PJ energy, but by realizing economic potential and decreasing energy consumption to 150 kWh/m^2/year it is possible to save 15 PJ energy, according to the study "Energy efficiency in buildings"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

[29] Statement on energy development 2007. – 2016
[30] Communication From The Commission, Action Plan for Energy Efficiency: Realising the Potential, COM(2006)545
[31] AS „Latvenergo" un AS Rīgas siltums publiskie gada pārskati.

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



Energy consumption in household and housing fund



	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

Given the standstill in energy efficiency 2000-2005 (see below), is can be difficult to realise the above-mentioned targets for 2016 and 2020; but given the high volume of new construction, an increase of standards in new constructions could be a crucial factor to realise the target. 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 not 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 looses in heating systems inside houses including losses in boilers is 25% in 2000 and that it will gradually decrease with 5%/decade until it reaches 90% in 2020. Then the increase will be only 1%/decade.

With this 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
Heating system efficiency in houses	75%	80%	81%	85%	90%	91%	92%
Net heat demand (kWh/m2)	173	168	158	128	111	92	76
Net heat demand relative to 2000	100%	97%	92%	74%	64%	53%	44%

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 block houses from the Soviet era. For the vision is only included data set for the start of each decade, the data for 2016 in the table above are not used.

This development is used for space heating of buildings for dwellings 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 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[32].

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

Power plant efficiencies	2000	2010	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

32 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.

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%
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 70% in 2000 to 80% in 2020 and 90% in 2040 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.

4. Demand for energy services

In this model is not included an automatic link of economic development (GDP growth) and energy consumption. Instead is included expected growth of energy consuming factors, such as heated floor area, transport, production in volume, not in value. These drivers are refered 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. 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[33].

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 41 m^2.

Consumption of heat and fuels of service sector buildings has increased 24% 2000 – 2005[34]. 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 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

[33] 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.
[34] 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.

growth is 5% higher given the increase in efficiency discussed above. It is further assumed that 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 to 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 to stop the expansion in electric heating, and that the electricity consumption will increase 15% 2005-2010 of the 2000 level, or 5% more than the expected increase in dwelling area, so the total increase 2000 – 2010 will be 47%. Then we assume that the increase in demand for electricity services will be 20%/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 three 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 floorspace in the sector + 20%/decade in the period 2010-2020 (67%). 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 5 times the 2000 level.

Industry and farming: We assume increase of 35% per decade (3%/year) until 2020 (following trends 2000 – 2005, then stable.

Construction: We expect doubling 2000-2010 because of increased activity, then stable on new higher level.

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 7% 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 Lavian ministry of transportation, statistics available online from ministerial website, Latvian version.

Bus passengers increased from 165.9 mill. in 2000 to 214,1 mill. in 2005 but decreased again to 208.8 mill. in 2006 (preliminary data). There is no data of distance travelled of bus passengers (in person-km), which is the information normally used for bus transport activity. Therefore number of passengers is used as a proxy for bus transport activity. There is no specific data on fuel consumption of buses, instead is used the estimate that 10% of diesel consumption for roads is used for buses. The increase 2000 – 2006 is 26%, if this trend continues until 2010 the increase is 43% in the decade 2000 - 2010. This trend is expected to continue until 2020 to reach 204% of the 2000-level. After 2020 the increase is assumed to be 10%/decade until 2040 and then stable on 2.5 times the 2000-level.

Use of passenger trains increased from 715 mill. passenger-km in 2000 to 892 mill. p-km in 2005 and 992 mill. p-km in 2006, an average increase of 5.6%/year, BUT 11% 2005-2006. In the 1990'ies use of passenger trains fell dramatically, to less than 1/3 of the previous level. The increase of 5.6%/year is expected to continue until 2030 and then level off to 1%/year. With this development, passengers train use in 2020 will be similar to the use in 1993 and in 2050 the use will be twice the 1993-level.

Passenger cars increased from 555,000 by 1/1-01 to 742,000 1/1-06 and 822,000 1/1-07. This is 7%/year in average during the period; but 11% during 2006. The increase of passenger cars is expected to continue with 7%/year until 2010 and then level off to 1%/year until 2020, when there will be 520 cars/1000 inhabitants equivalent to Western European (EU-15) average.

With these forecasts is expected that Latvia will follow a 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 use of cars (in person-km of transport) per car is unchanged, so the number of personal cars can be used as a proxy for car use. 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. 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 is expected that the low increase in petrol use is caused by 10% increase in car efficiency combined with a change from petrol to diesel vehicles

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

Personal transport	1995	2000	2006	2010	2020	2030	2040	2050
Car	60	100	148	197	217	217	217	217
Bus	111	100	126	143	204	224	247	247
Rail	192	100	139	172	338	582	640	704

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 13291 mill ton-km in 2000 to 19779 mill tkm in 2005, but then decreased to 16831 mill tkm in 2006. 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 until 2020, after which we assume an increase of 2%/year until 2040 and then no further growth.

Road freight increased from 4789 mill ton-km in 2000 to 8547 mill. t-km in 2005 and 10936 mill. t-km in 2006. This is an increase of almost 15%/year; but the increase in 2006 was 28%. We expect the average rate of 15%/year increase to continue until 2010; but then decrease to 5%/year until 2020, as the large increase 2000 – 2006 is not sustainable and much above the economic growth of Latvia. After 2020 no further growth is expected in road freight.

Freight transport	1995	2000	2006	2010	2020	2030	2040	2050
Road	38	100	228	405	659	659	659	659
Rail	73	100	127	148	219	267	326	326

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

5. 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}[35]:

- Cogeneration potential in Riga - 50 MW_{th}[36];
- 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}.

[35] Latvijas Siltumuzņēmumu asociācijas, AS „Rīgas siltums", AS „Latvenergo" informācija.
[36] Šī potenciāla apgūšana neatstāj ietekmi uz esošo koģenerācijas staciju darbības režīmiem, jo to siltumapgādes zonas savā starpā nav savienotas.

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 46% of the demand of each of these sectors. 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 transport, initially using the full potential for road transport in 2020 (5.5 PJ), covering 7% of road transport fuels.
In 2030 we expect that railways will be more electrified, covering 53%of rail transport (from 23% in 2020 and 13% 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 63% and 40%. We expect that hydrogen will cover 20% of road transport needs and 10% of railroad needs for energy.
In 2050 we expect that the railways will be 80% electrified with the remaining energy needs from hydrogen while road transport will be covered by 57% electricity, 34% hydrogen, and the rest mainly from biofuels.

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.

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- can require energy storages and flexible energy use. The total fraction of intermittent electricity production in 2020 is 15% raising to 16% in 2050. To cope with this, the regulation capacity of the hydro-power 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[37]. There is no need for special storage of electricity in the system, given this low fraction of intermittent power (The

[37] 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.

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 is also introduced some flexible consumptions:
- hydrogen production for transport.
- electric cars with batteries that can be charged at different times at night

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

For solar heating there will be some need for seasonal storages 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.