

# **A vision for Lithuania based on INFORSE's Vision2050**

## **-Background note**

Updated December 02<sup>nd</sup> 2010

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 –Europe (INFORSE-Europe) – Europe and Bendrija Atgaja. The vision includes growth in most sectors.

All comments are welcome.

## **Renewable Energy Potentials**

### **Windpower:**

Officially the following windpower potentials are available:

-850 GWh, National Energy Efficiency Programme, Lithuania, 2004

-1200 GWh of which 200 GWh offshore, EU Communication SEC 2004-0547, country profiles

The official sources do not give installed capacities or capacity factors for the potentials. With a capacity factor of 2000 full-load hours per year, the installed capacity needed to produce 850 GWh would be 425 MW while the installed capacity to produce 1200 GWh (1.2 TWh) would be 600 MW.

Windpower engineers from the company Enercon, have stated that the potential is larger than the official estimates, because they find that the area suitable for windpower is substantially larger than currently included in official figures.

Windpower experts from Lithuania expect that the potential near the coast North of Klaipeda is about 500 MW, while there are several other promising areas, so the total potential is not below 1000 MW.

In addition to above-mentioned potentials, it is possible to make a large windpower park in the Baltic Sea as part of a Swedish – Lithuanian cable project. If part of such a park becomes an investment from Lithuanian side, this could add more windpower capacity; but most likely at a higher cost than the land based turbines.

An existing 600 kW turbine near Palanga has an annual production of 1500 MWh, equivalent to a capacity factor of 2500 full load hours.

In the current version of the vision is used a windpower potential of 1000 MW with 2000 full load hours, assuming that the existing 600 kW windturbine is situated at an extraordinary good site. This gives an annual windpower production of 2 TWh (2,000 GWh). In addition we include the possibility of an additional 1000 MW offshore. This could be via the Lithuanian – Swedish cable. After 2040 an additional 200 MW offshore potential is included.

At the end of 2007 52 MW windpower was installed and the windpower production was 106 GWh. Preparation is already underway for the installation of an additional 148 MW of windturbines, so the total should reach 200 MW in 2010. The Lithuanian government has tendered grid connection

for these 200 MW and offered a feed-in tariff of 0.22 Lt/kWh, which is expected to increase in 2009. This has drawn the interest of a number of investors and most probably this capacity will be installed not later than 2010. For this vision it is expected that the development will continue 2010 – 2020 with installation of an additional 1000 MW: 800 MW on land and 200 MW offshore. The remaining short-term off-shore potential of 800 MW is expected to be developed in the period 2020 - 2030; e.g. using the coming Lithuanian – Swedish power line for transmission of the power to the coastline. The additional long-term potential of 200 MW offshore is expected after 2040.

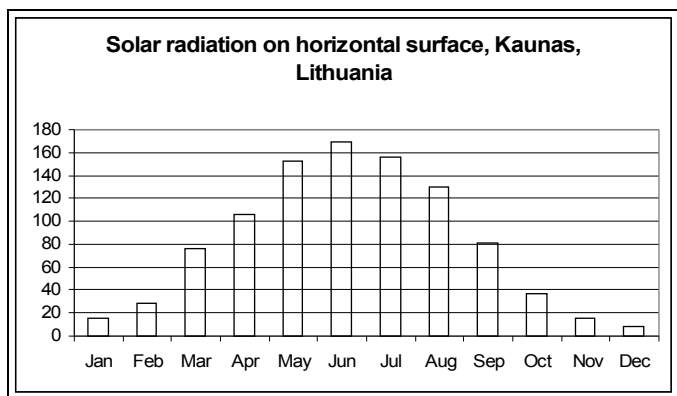
Thus, the total installed capacity is expected to be:

- 200 MW in 2010
- 1200 MW in 2020
- 2000 MW in 2030 - 2040, using expected additional offshore parks
- 2400 MW in 2050

The capacity factor is expected to be 2000 full-load hours, even though it will in practice be larger for offshore installations.

In this way, onshore wind power will be at maximum capacity in 2030, while it'll be 2050 for offshore.

## Solar Energy



The energy in solar radiation in Lithuania is on average 1000 kWh/m<sup>2</sup> on a horizontal surface, ranging from 926 to 1042 kWh/m<sup>2</sup> for different locations.

The graph shows monthly variation of the energy in the solar radiation for Kaunas, where the total annual solar energy input is 976 kWh/m<sup>2</sup>

Scale: kWh/m<sup>2</sup> on horizontal surface

Source: National Solar Programme 2000 – 2005, Lithuania

The area of roofs in Lithuania is 150 km<sup>2</sup>. It is expected that half of that area is facing North, and that half of the remaining area is not useful because of different limitations such as major shadows from trees and from other buildings. That leaves an area of 37 km<sup>2</sup> that could be used to harness solar energy.

The area used for solar energy is divided between:

- Solar collectors for hot water (directly used domestically for service sector, industrial heat demand or eventually district heating) with an annual yield of 400 kWh/year (about 40% efficiency) and
- Solar electric cells (PV-cells) with an annual yield of 100 kWh/year (about 10% efficiency).

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.

The maximum use of solar energy is limited to:

- 1/3 of buildings heat demand (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 2030. Until 2030 we suggest to limit solar heating installations to cover part of domestic hot water demand, which is about 20% of total domestic heat demand.

There is no market for solar energy installations in Lithuania 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<sup>2</sup>/year (total 100,000 m<sup>2</sup> (2.04%) installed in 2020)
- 2020 – 2030: 80,000 m<sup>2</sup>/year (total 900,000 m<sup>2</sup> (18.3%) installed in 2030, covering 4% of domestic heat demand)
- After 2030: 200,000 m<sup>2</sup>/year until 2050. Above-mentioned limits are not reached in 2050.

The installed area for solar electric generation (PV) is only expected to take off from 2020. After 2030 it is expected to expand stronger than solar thermal, leading to all the potential area being used in 2050. Development of PV in this fashion will then resemble:

- 2020-2030: 100,000 m<sup>2</sup>/year (total 1,000,000 m<sup>2</sup> (5.55%) installed in 2030)
- 2030-2040: 500,000 m<sup>2</sup>/year (total 6,000,000 m<sup>2</sup> (33%) installed in 2040)
- 2040-2050: 1,200,000 m<sup>2</sup>/year (total 18 km<sup>2</sup> (100%) installed in 2050)

With this development, 4.9 million m<sup>2</sup> will be used for solar heating and 18 million m<sup>2</sup> will be used for solar electric generation in 2050. This is equal to 7 m<sup>2</sup>/person for solar energy use in 2050 in total. Most of this is expected to be on rooftops. This area is of course not a maximum and it leaves room for additional solar installations after 2050.

## **Biomass**

The potential for solid biomass consists of wood and straw available for energy purposes. In addition there are potentials for bio-fuel for transportation, biogas and energy plantations; they are all treated separately below.

Wood is already used to a large extent today, mainly for domestic heating. From use of 26 PJ (7.2 TWh, IEA statistics) in 2000 it has increased to 30 PJ in 2005 (IEA online statistics). The potential is 35.3 PJ (9.8 TWh) according to Lithuanian Energy Institute. Use of most of this potential (98%) is included in this vision for 2010 and 100% for 2020.

Another estimate is that the economic potential for wood including firewood, wood residues from forestry and wood industries is 37 PJ (5.1 mill. m<sup>3</sup>) in 2010 increasing to 43 PJ (5.9 million m<sup>3</sup>) in 2025.

There is a potential for straw for energy use in Lithuania, even though this source is not used today. The total production of straw is 2.55 million tons/year of which 1.75 million tons/year is used for agriculture and 0.53 million tons/year is lost on the fields according to the Lithuanian Energy Institute. That gives a technical potential of 0.27 million ton/year for energy use. The Lithuanian Energy Institute estimates that with changes in agricultural practices and better collection methods, the potential will increase by 2020 to 0.9 million ton/year equal to 5.4 PJ (6 GJ/ton). Straw is hardly used today in Lithuania. This is not expected to change before 2010; while the full potential of 5.4 PJ is expected to be used in 2020 in this vision.

With this, the total solid biomass potential is 40.7 PJ, combining the 35.3 PJ of wood and 5.4 PJ of straw.

### **Liquid Bio-fuel**

The potential for liquid bio-fuel is expected to be 4 PJ, equivalent to 167,000 ha (1670 km<sup>2</sup>) of agricultural land planted with rape seed that yields 290,000 tons of seed (1.75 tons/ha, average of 2.2 t/ha for winter rape seed and 1.38 t/ha for summer rape seed) from which can be extracted 110,000 tons (38%) according to Lithuanian Energy Institute. With an energy content of 36 GJ/ton (10 MWh/ton) this is equal to 4 PJ.

Rapeseed production in 2005 was 239,000 tons of seeds (giving about 3.3 PJ) and is increasing. In 2006 the consumption of biodiesel (rape seed methyl ester) was 18 ktoe equal to 0.75 PJ and the consumption of ethanol for energy 8.5 ktoe equal to 0.36 PJ, in total 1.11 PJ. A substantial part of the biofuel production is exported.

According to Lithuanian law all diesel sold in the country should be blended with 2% biodiesel and all petrol with 2% ethanol. This law has been in force since 2006. In 2005 the consumption for transport of diesel and petrol was 762 ktoe and 334 ktoe, in total 1096 ktoe equal to 46 PJ. The required biofuel blending is then 0.9 PJ, a target that seems to be fulfilled.

The potential of 4 PJ is expected to be fully used in 2010 in the country (no more export). This might be below the EU target for renewable energy in transport for 2010 because of the growing transport fuel demand.

### **Biogas**

For the potential for biogas (from waste water, agriculture etc.) we use the figure from Lithuanian Energy Institute of 48 million m<sup>3</sup> biogas/year with an energy content of 1.01 PJ (0.28 TWh). This is divided in 95.6% from agriculture, 3.3% from wastewater treatment and 1.1% from food industry. The potential from industry seems small compared with potentials from other countries and the potential of using food waste from institutions and sorted waste from households. When waste incineration is not used, as in Lithuania, the organic part of the waste should preferably be treated separately to avoid methane generation in landfills. This separated waste can give an additional biogas potential.

For the potential of landfill gas we use the figure from Lithuanian Energy Institute of 24 million m<sup>3</sup>/year with an energy content of 0.36 PJ (0.1 TWh). The total biogas potential including landfill gas is then 1.37 PJ.

We expect a rapid development of biogas, resulting in the full potential being utilised by 2020.

## **Solid Biomass Crops**

The potential for energy crops is dependent on the excess land of agriculture and other unused land areas. It is estimated by the Lithuanian Biomass Energy Association (LITBIOMA) that there is 500.000 ha (5000 km<sup>2</sup>) of unused land and low-productive agricultural land. The total agricultural area in Lithuania is 31500 km<sup>2</sup>.

In this vision we have included that half of the unused and low-productive land is used for energy, equal to an area of 2500 km<sup>2</sup> (250,000 ha). With a yield on the land of 9 tons dry matter/ha and an energy content of 4.9 MWh/ton<sup>1</sup> of dry matter, the corresponding energy potential is 11 TWh = 40 PJ. This is the figure obtained for willow-plantations in Southern Scandinavia. Similar yields can be achieved with other fast-growing trees such as poplar. With GMO plants higher yields are possible; but we do not recommend that both because of the problems with uncontrolled spreading of genetically modified organisms and because the high-yield GMO plants typically require more inputs in the form of fertiliser and pesticides.

We expect the development of energy plantation to take off after 2010 and that the use of 80% (2000 km<sup>2</sup>) of the potential area is utilised by 2020. By 2030 we expect that the full potential of 2500 km<sup>2</sup> to be used. The expansion from 2010 - 2020 will require a substantial increase in the capacities of companies involved and a national campaign with promotion, planning regulation, knowledge centre etc. Presently LITBIOMA only expect an expansion to 11,500 ha and an official energy strategy includes an energy production from this source of 3 PJ (70 ktoe) in 2025. By 2050, we foresee a fairly sharp drop in energy forest usage from 100% in 2045 to 44%, as diversification, lower demand and efficiency increases all combine to make usage of the full potential unnecessary.

## **Geothermal energy**

In the Central and Western part of Lithuania, in areas of 42,500 km<sup>2</sup>, there is a potential for geothermal heat in deep water layers with an energy content of about 270 million tons of oil equivalent (11,000 PJ), according to the article "Geotermija is Kalinos ciklo perspektyvos Lietuvos energetikoje" by Vita Resteniene et. al, Lithuanian Association of Geologists. Even more geothermal energy is available in crystalline rock formations, up to 46 billion tons of oil equivalent (1,900,000 PJ). Based on test drilling it has been found that from 2000 m deep aquifers (Cambrian rock formations) water with temperatures 65- 90°C can be extracted. From layers around 1000 m below ground (Devon rock formations) water of 35-42°C can be extracted. From crystalline rock below 3500 m there is a potential to extract heat of 120-150°C with hot-dry-rock techniques.

As a potential could be chosen annual extraction of 1% of the energy in the deep water layers, equal to 110 PJ. It will only be useful for low-temperature heat demand such as space heating.

In the current version of the vision, we have reduced the potential to 2.9 PJ, equal to the potential proposed by Mr. Marijus Franckevicius, Energy Agency in Lithuania (0.8 TWh)<sup>2</sup>. This potential is expected to be utilised by 2020.

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<sup>1</sup> 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.

<sup>2</sup>Presentation "Progress on Renewable Energy in Lithuania since Accession" at the conference "New Europe, New Energy, renewable energy for an expanded EU", 26/9-2006, Milton Keynes, UK by Marijus Franckevicius, Energy Agency, Lithuania.

## Hydropower

The hydropower production was 1.2 PJ (0.34 TWh) in 2000 and increased to 1.6 PJ in 2005 (IEA statistics). The potential for additional hydropower on small rivers has been estimated at 1.5 PJ (0.4 TWh) on small rivers and about 3 PJ on large rivers. In 2007 the small hydropower production was 96 GWh from 26.4 MW installations of which 12.7 MW were already installed in 2000. Thus the additional capacity since 2000 has increased hydropower production with 50 GWh equal to 13% of above-mentioned potential for small hydropower. We have not included the development of hydropower on large rivers in this vision for environmental reasons. Therefore we have only included a potential of 2.7 PJ, combining existing use, improvements of existing hydropower stations and most of the potential for expansion on small rivers. Part of the potential is already used and the remaining is expected to be developed 2010 - 2020.

## Efficiency Potentials

For the vision we use the finding 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](http://www.factor10.de)). Even though the increase of efficiency is cost effective, 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 45 years that the vision covers. Thus, there are no 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 freight to reach a factor 4 efficiency increase 2000 - 2050:

- 2000 – 2010 5% in total (10% for road freight, domestic and service electricity use, 0% for industry)
- 2010-2020: 1%/year (less for road freight, domestic and service electricity use, more for industry)
- 2020-2030: 4%/year
- 2030-2040: 4%/year
- 2040-2050: 4.6%/year

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 we expect implementation of technologies to regain brake-energy from vehicles.

Due to the situation in Lithuania where a large part of personal vehicles are imported from Western Europe, the increase in efficiency is effectively delayed 5-10 years compared with Western Europe. Therefore the increase in personal transport efficiency is expected to start slower in Lithuania than in Western Europe.

The following increase in efficiency is included in the vision for personal road transport:

- 2000 – 2010 5% in total, due to change to better cars
- 2010-2020: 1%/year
- 2020-2030: 2%/year

- 2030-2040: 3%/year
- 2040-2050: 5%/year

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.

### Efficiency of heating

In Lithuania, total heat consumption of dwellings was 23.4 TWh in 2001 of which 18.6 TWh was for space heating and 4.8 TWh (20%) for hot water, according to National Energy Savings Program in Lithuania. The program found the technical potential for heat savings in dwellings to be 8.2 TWh (35%) and the economic potential to be 5.2 TWh (22%). It is not specified how fast this potential can be realised. It is also not known how much of the potential that covers improvements in heating systems and how much cover building improvements. For this vision we assume that the potential can be realised from 2005 until 2020 with increase of heating system efficiency from 80% to 85% combined with a 17% reduction of specific heat losses. For 2000 – 2005 the efficiency increase have been 0.7% while after 2015 we assume continued efforts for energy efficiency in line with ambitious implementation of EU regulation and increasing energy prices, leading to an increase of building efficiency of 2.5%/year equal to 22% per decade. This is similar to the assumptions for visions for Western Europe. ¼ of these improvements are expected to be in the heating system while the rest is expected to be due to building improvements.

This gives the following specific heat demand and heating system efficiencies of buildings, compared with 2000:

|      | Specific heat demand | Heating system efficiency |
|------|----------------------|---------------------------|
| 2000 | 100%                 | 80%                       |
| 2010 | 95%                  | 80%                       |
| 2020 | 83%                  | 85%                       |
| 2030 | 69%                  | 90%                       |
| 2040 | 55%                  | 92%                       |
| 2050 | 44%                  | 94%                       |

Public service area is 30.1 million m<sup>2</sup>. Technical potential for heat savings has been found to be 2.8 TWh while the economic potential has been found to be 2.5 TWh (8.3%) by National Energy Savings Program. We also expect that this is realised 2005-2020 in this vision. Further we expect that the energy efficiency potential for private service is similar (8.3%) and realised in the same period. We expect the heating system efficiency increases to increase in parallel with the domestic sector (from 80% to 85%) while we expect no efficiency increase until 2005, following statistics and efficiency due to new efforts after 2015 to result in efficiency gains of 2.5%/year as in the domestic sector.

This gives the following specific heat demand and heating system efficiencies of service sector buildings:

|      | Specific heat demand | Heating system efficiency |
|------|----------------------|---------------------------|
| 2000 | 100%                 | 80%                       |
| 2010 | 97% (92% observed)   | 80%                       |
| 2020 | 96%                  | 85%                       |
| 2030 | 80%                  | 90%                       |
| 2040 | 64%                  | 92%                       |
| 2050 | 51%                  | 94%                       |

### 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.

From the loss in the CHP plants 57.5% in 2000 (including Ignalina Nuclear Power plant that is registered as a CHP plant) is expected increases already in 2010 with closure of Ignalina and renovation of other power plants.

From IEA Statistics the efficiencies of Lithuanian power plants divided in sources for 2000 can be estimated:

| Powerplant efficiencies | Oil-based | Gas based | Nuclear (Ignalina) |
|-------------------------|-----------|-----------|--------------------|
| Electric                | 32%       | 19%       | 33%                |
| Total                   | 64%       | 70%       | 34%                |

(Efficiencies including own consumption)

With the closure of Ignalina by 2010, the other power plants will be able to run with higher power production, and can therefore increase their efficiencies without technical improvements. This is particular the case for the gas-fired power plants.

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

| Power plant efficiencies | 2010  | 2020 | 2030 | 2040 and later |
|--------------------------|-------|------|------|----------------|
| Electric                 | 27.7% | 45%  | 46%  | 46%/55%*       |
| Heat                     | 13.7% | 40%  | 39%  | 39%/0*         |
| Total                    | 41.4% | 85%  | 85%  | 85%/60%*       |

\* Figures for power-only plants.

The electric efficiencies are based on power plant efficiency data used for Danish energy planning for new plants (Danish Energy Authority, "Technology Data for Electricity and Heat Generating Plants" from [www.ens.dk](http://www.ens.dk)), with reductions due to only partial replacement of power plants.

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.)<br>53-58% (full heat)<br>6% lower at 50% load | 59-64% (no heat prod.)<br>54-60% (full heat)<br>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)<br>2.5% lower at 50% load                          | 48.5% (100% load)<br>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%<br>5% lower at 50% load                                       | 37-45%<br>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 CHP power plants with efficiencies of 38-48%, depending in size. 95% of the fuel is expected to be biomass.

Also the efficiency of the electricity network is expected to increase; but the large electric grid losses (18% of production, 21% of consumption) are partly due to losses in Lithuania's large pump-storage plant. This plant is serving Ignalina; but also other power plants, including Russian nuclear power plants. Therefore we only expect that the grid losses are reduced by 2020 to 16.4% of production (5.3% of consumption) and then remain on that level.

The losses in the heat grid were 25% of production (33% of consumption) in 2000. We expect these losses to be reduced to 19% of production (23% of consumption) until 2020 and then remain on that level until 2040. Then the loss is reduced further to 20% of consumption.

A phase-out of nuclear power in 2009 is included in the vision.

### Demand for energy services

In this model we don't include an automatic link of economic development (GDP growth) and energy consumption. Instead we include expected growth of energy consuming factors, such as heated floor area, transport and production in *volume*, not in *value*. These drivers are referred to as energy service demands.

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

### Heating (district heating + fuels):

Construction of dwellings have increased from 460,000 m<sup>2</sup>/year as an average 2000 – 2003 to 699,000 m<sup>2</sup> in 2004 and 651,000 m<sup>2</sup> in 2005 according Lithuanian Statistical Department (online statistics of useful floorspace). In 2006 in increased further to 772,000 m<sup>2</sup> and in 2007 to 960,000 m<sup>2</sup>. From 2008-2009 the international crisis is evident, as total stock of dwellings decreased by 165,000 m<sup>2</sup>.<sup>3</sup>

Dwelling area has increased from 79.4 million m<sup>2</sup> in 2001 to 80.2 million m<sup>2</sup> in 2004, an increase of 800,000 m<sup>2</sup> or 260,000 m<sup>2</sup>/year according to Lithuanian Statistical Department (online statistics on housing stocks). From 2004 to 2007 the area increased to 82.1 million m<sup>2</sup>, an increase of 1.9 million m<sup>2</sup> or 630.000 m<sup>2</sup>/year; but in 2008 the construction then drastically reduced.

The difference between constructed dwelling area and increase in dwelling area is demolition of dwellings that can be estimated to 200,000 m<sup>2</sup>/year.

With the increase in construction in 2004-2006, the dwelling area is growing faster, 450,000 – 600,000 m<sup>2</sup>/year under the assumption that demolition continues at 200,000 m<sup>2</sup>/year. Because of the financial crisis, the construction is expected to be reduced to the average of 2000-2007, leading to an increase of 400,000 m<sup>2</sup>/year in the years 2008-2010. For the total decade 2000-2010, the increase will then be 3.8 million m<sup>2</sup>, adding 4.8% (or 0.94% p.a.) to the dwelling area. If we assume a steady growth rate of 0.96% going forward, this will result in the following development of dwelling areas compared with 2000:

2000: 100%  
2005: 102%  
2010: 105%  
2015: 110%  
2020: 115%  
2025: 120%  
2030: 126%  
2035: 132%  
2040: 139%  
2045: 145%  
2050: 152%

Construction of non-residential buildings has increased from 704,000 m<sup>2</sup> in 2000 to 1,870,400 m<sup>2</sup> in 2008, but has then decreased in 2009 to 1,725,000. The total expected construction for the decade is taken as the sum of the construction 2000-2009 + 10% for the remaining year. This is equal to 11.65 million m<sup>2</sup> + 10% = 12.8 million m<sup>2</sup>. Of this, service sector buildings are 39%; equal to 4.99 million m<sup>2</sup>.

Service sector building area in 2000 was 30 million m<sup>2</sup>. Thus, the relative stock increase of 4.99 million m<sup>2</sup> of the decade as mentioned above, means an increase of 16-17% 2000-2010 or about 1.5% p.a. on average. This is expected to continue until 2020, then decrease to 10%/decade (about 0.96% p.a.) until 2040 and then remain stable. This gives the following development of service sector area, both public and private:

2000: 100%  
2005: 108%  
2010: 116%

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<sup>3</sup> Statistikos Departamentas

2015: 125%  
2020: 131%  
2025: 138%  
2030: 144%  
2035: 151%  
2040: 159%  
2045: 159%  
2050: 159%

Industry consumption of heat and fuels rose 23% 2000-2010 and is expected to remain stable, following the Western European trends where industrial production is developing in quality, not in quantity.

Agriculture is expected to continue at the same level of activity that it had in 2000, measured in product volume that drives energy consumption. Demand rose 16% 2000-2010, and we expect it to remain stable at this level.

Construction demand for heat & fuel rose to 136 in 2005 and 156 in 2010. While this may turn out to be too high, we assume it will stabilize at this level.

#### Electricity:

Household Sector: electricity demand grew by 54%, using IEA 2008 data as proxy for 2010. In the long run we expect electricity demand to follow floor space + 20%. This will lead to an energy service level in 2050 of 182% of the 2000 level.

Service sector: service sector electricity demand grew 74% 2000 – 2010. While we also expect that in the long run, it will grow to 20% more than floor space in 2050 relative to 2000, this level was almost reached in 2010, and it appears the growth of the decade was unsustainably large. We therefore expect electricity demand to stay almost constant over the next 40 years. If an extremely modest growth of 0.1% p.a. is assumed until 2040, service sector electricity demand will plateau at 179% in 2040 compared to 2000.

Industry: Demand increased by 22% 2000 – 2010. We expect a further 10% increase until 2020 at which level it will remain stable.

Agriculture: We assume increase an increase of 1%/year until 2020 (because of increased mechanisation), then stable.

Construction: Demand rose by 23% in 2010 (using IEA 2008 data as proxy) compared to 2000. We expect it to keep rising at a modest 1% p.a. until 2020, and then stabilize.

#### Transport:

Passenger car use has increased in Lithuania, with the number of cars increasing from 1.17 million (315 cars pr 1000 inhabitants) in 2000 to 1.56 million (468 per 1000 inhabitants) in 2009, an increase of 33% or 4.66%/year.

Public transport has increased from 3873 million person-km in 2000 to 4790 mill. person-km in 2007, an increase of 23.6%. This includes a decrease in train use from 611 million person-km in 2000 to 428 million person-km in 2009 (70% of 2000-level) and a slight increase in bus use from 2,754 million passenger-km in 2000 to 2,774 million passenger-km in 2009 – although there was a quite significant increase around mid-decade.

Source: Lithuanian Statistical Department, online data.

A significant increase in passenger car ownership of 42% took place between 2000 and 2010, despite the financial crisis. This equals an annual growth rate of 3.6%, which we regard as

unsustainable in the long run. We therefore expect the growthrate to drop to an average of 1.7% p.a. until 2030, at which point personal car ownership has doubled compared to 2000.

Car transport is then expected to remain stable at a level of 700 cars/1000 inhabitants; which is higher than many Western European countries.

Bus use rose by 50% in 2005, but then fell to just 2% above 2000 level in 2010. We expect the decline to halt at this level and growth in bus use to resume at 2% p.a. until 2040, then 1% p.a. until 2050, reaching a level of 2.04 times the 2000 level.

The use of trains fell sharply by 42% in 2010 (using 2009 data) compared to 2000. We expect the decline to halt around this level and growth in passenger rail transport to resume at an average of 2% p.a., resulting in a 2050 level of 1.29 times the 2000 level.

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

|      | Cars | Train | Buses etc. |
|------|------|-------|------------|
| 2000 | 100% | 100%  | 100%       |
| 2005 | 122% | 70%   | 150%       |
| 2010 | 142% | 58%   | 102%       |
| 2015 | 154% | 64%   | 112%       |
| 2020 | 168% | 71%   | 124%       |
| 2025 | 183% | 79%   | 137%       |
| 2030 | 200% | 87%   | 151%       |
| 2035 | 200% | 96%   | 167%       |
| 2040 | 200% | 106%  | 184%       |
| 2045 | 200% | 117%  | 194%       |
| 2050 | 200% | 129%  | 204%       |

Air transport is not included in this vision.

In 2009 30,061 million tons-km (tkm) of goods were carried; 11,888 million tkm by train, 17,757 mill. tkm with trucks. This was an increase of 49% above 2000 (20,149 mill.tkm), with most increase in trucking (2.3 times increase since 2000), followed by 1.3 times increase in freight by train. However, both road and rail freight transport were at a significantly lower level compared to 2008.

If we compare the growth we previously expected to what has happened in this sector, it appears likely that the growth rates observed so far, 8.7% p.a. for road freight 2000-2010 and 2.9% p.a. for rail freight (in both cases using 2009 data as proxy), have been too strong to be sustainable in the long run. The long-term transport system development strategy by the Lithuanian government June 23, 2005, foresaw a doubling of road freight transport 2005 – 2020, which would mean a 4 times increase of the 2000 level. Rather, we expect to see a more modest/balanced growth rate of 2% p.a. 2015-2025, 1.5% p.a. 2025-2040 and 1% p.a. 2040-2050, where it will stabilize at around 4 times the 2000 level.

For this vision we include the growth of rail freight transport by 45% 2010-2025 – equal to an annual growth rate of 2.5%, and then an increase of 2%/year until 2040, then 1.5% p.a. until 2050 and then stable on almost 3 times the 2000 level.

This gives the following freight transport relative to 2000:

|       | Road | Rail |
|-------|------|------|
| 2000: | 100% | 100% |

|       |      |      |
|-------|------|------|
| 2005: | 205% | 140% |
| 2010: | 229% | 193% |
| 2015: | 252% | 151% |
| 2020: | 279% | 171% |
| 2025: | 300% | 193% |
| 2030: | 323% | 213% |
| 2035: | 348% | 235% |
| 2040: | 366% | 254% |
| 2045: | 385% | 273% |
| 2050: | 404% | 294% |

Pipeline use: stable until 2020, then reducing because of less European oil and gas demand till 70% of today's level in 2050.

### **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. With regards to fuel shift in the power sector with construction of new power plants, we foresee a more rapid development.

Fuel shift in transport is starting with introduction of biofuels in transport, initially using the full potential for road transport in 2020, covering about 5-10% of road transport fuels.

In 2030 we expect that railways will be more electrified, covering 53% of rail transport (up from 22.5% in 2020) while we also expect that electricity will cover 10% of energy demand on roads, through the use of electric vehicles.

In 2040 we expect that the use of electricity in rail and road transport will increase to respectively 90% and 60%. We do not expect hydrogen technology to develop to a point where it will really matter much.

In 2050 we expect that the railways will be fully electrified while road transport will be covered by 88.5% electricity and the rest from biofuels.

### **Fossil fuels**

The small remaining oil production is expected to decrease gradually, assuming an optimistic reserve/production (R/P) ratio of 25 in 2005, which is possible if some new, small oil deposits are found. In 2000 the R/P ratio was then 30. However it should be noted that R/P ratios are always somewhat misleading, as production of a non-renewable resource can never be held at a constant level and suddenly fall to 0.

We expect that the remaining fossil fuel use will be covered by imports.

### **Energy storages**

High reliance on intermittent renewable energy – wind and solar- will require efficient energy storage and flexible energy use. The total fraction of intermittent electricity production in 2020 is 21% rising to 33% in 2030 and further to 40% in 2050. From 2030 this will require special electricity storage; but use of the current hydro pump-storage should be sufficient together with some electricity exchange with neighbouring countries and flexible consumption. This pump-storage capacity is 600 MW (Energy: Yearly Statistics; Eurostat 2005); but there are plans to

increase it to 800 MW. It is also helpful for regulation before 2030. The closure of nuclear power will free the existing hydro pump-storage electricity capacity. The flexible consumption in the form of large heat pumps, hydrogen production and electric vehicles is 3% in 2040 increasing to 15% in 2050.

In the electricity sector we also introduce some flexible consumption:

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

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

### **About this note**

This note was developed by Gunnar Boye Olesen, INFORSE-Europe in cooperation with Saulius Piksrys, Bendrija Atgaja for the Vision2050 for Lithuania. Read more about the vision for other countries at [www.inforse.org/europe](http://www.inforse.org/europe). Please send comments to [ove@inforse.org](mailto:ove@inforse.org).

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