

A vision for Belarus based on INFORSE's Vision2050

- Background note.

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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 Minsk Division of International Academy of Ecology. The vision includes growth in most sectors.

The current version of this paper will be improved gradually as new and consolidated information is developed. All comments are welcome.

Renewable Energy Potentials

Windpower:

A few windturbines work well in Belarus at the moment as it has been showed that more than 2000 full load hours are possible. The turbines should, however, be designed for low wind conditions.

We find that there are reasonable sites for windpower, mainly in NW Belarus the potential is not less than 2000 MW with average annual full load hours of 2000.

We expect in this vision that the development of windpower will grow to:

-20 MW by 2010

-1000 MW by 2020

-2000 MW by 2030 and then remain stable

Solar Energy

The energy in solar radiation in Belarus is about 1000 kWh/m² on a horizontal surface, with smaller regional variations.

The solar collector area is in this vision limited to 10 m²/capita, e.g. 74 mill. m²., but the full area might not be used in this vision.

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 that also have higher efficiencies.

The use of solar energy is limited to:

- 1/3 of buildings' space-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 from 2030. Until 2030 we have limited solar heating installations to cover 60% of domestic hot water demand, equal to about 12% of domestic total heat demand (assuming 20% of total heat demand is used for hot water and 80% for space heating), estimated.

There have been introductions of solar heating in Belarus, but a commercial sector does not exist yet. 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 m²/year (total 100,000 m² installed in 2020)
- 2020 – 2030: 90,000 m²/year (total 1,000,000 m² installed in 2030), producing 1,4 PJ
- 2030 - 2040: 500,000 m²/year
- 2040-2050 faster development until 2050 when there then would be 22 mill. m², equal to 3 m²/person

The installed area for solar electric generation (PV) is expected to follow take off as solar thermal from 2020; but to expand stronger than solar thermal from after 2030, leading to the potential area of 36 mill. m² used in 2050.

With this development, 22 mill m² will be used for solar heating and 36 mill. m² will be used for solar electric generation. This is equal to about 8 m²/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 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. From primary supply of use of 41 PJ (IEA statistics) in 2000 it has increased to 52 PJ in 2005. The potential is 147 PJ according to Belarus experts (147 PJ = 3.5 Mtoe which is the lower level of the potential of 3.5 – 4.5 Mtoe¹).

The increasing trend from 2005 to 2010 is expected to be double until 2010, and 80% of the potential is expected to be used in 2020. This will give the following use of wood for energy:

- 74 PJ in 2010
- 118 PJ in 2020
- 147 PJ in 2030

[?? CHECK THIS FIGURE, WHAT DOES IT INCLUDE]

¹ Возможности использования альтернативных источников энергии в Республике Беларусь, 2004, p.46

Straw is to a large extent burned on the field. An estimation of the potential that could be used is 6-9 mill. tons /year. In this vision we include a potential of 5 mill. Tons of straw per year. With an average energy content of straw of 4 MWh/ton, 5 mill. Tons per year of straw has an energy content of 20 TWh equal to 72 PJ.

Straw is hardly used today for energy today in Belarus. This is not expected to change before 2010; while half of the potential 36 PJ is expected to be used in 2020 in this vision and the full potential in 2030.

In total the solid biomass potential is then 219 PJ, combining the 147 PJ of wood and 72 PJ of straw.

Liquid Bio-fuel

[The potential for liquid bio-fuel is expected to be XX PJ, equivalent to XX ha of agricultural land planted with rape seed that yields XX tons of seed (XX tons/ha from which can be extracted XX tons (38%) according to XXX. With an energy content of 36 GJ/ton (10 MWh/ton) this is equal to XX PJ. 10% of the potential is expected to be used until 2010 and 100% by 2020. This is below the EU targets for renewable energy in transport, but this target can also be met with other means than bio-oils.][SHOULD WE INCLUDE LIQUID BIOFUEL, IF YES, HOW MUCH?, E.G. 4000 KM² AS FOR ENERGY PLANTATIONS]

Biogas

For the potential for biogas (from waste water, agriculture etc.) is used the figure from Belarus experts² of 24 PJ (6.7 TWh). This is primarily from agriculture.

When waste incineration is not used, as in Belarus, the organic fraction of waste should preferably be treated separately to avoid methane generation in landfills. This separated waste can give an additional biogas potential.

The potential of landfill gas is included in above potential, but is only a small part of the total.

Biogas for energy is not developed in Belarus at the moment, which we do not expect to change before 2010. Then we expect a large development of biogas, resulting in the full potential utilised by 2030.

Energy Crops

The potential for energy crops is dependant of the excess land of agriculture. There is substantial unused land in Belarus, including areas too humid for profitable normal agriculture. It is estimated that 400,000 ha (4000 km²) is abandoned but fertile agricultural land that can be used for energy crops such as energy forests.

With a yield on the land of 7 tons dry matter/ha and an energy content of 4.9 MWh/ton³ of dry matter, the corresponding energy potential is 13.7 TWh = 49 PJ. This is the figure obtained as 20-30% below willow-plantations in Southern Scandinavia, where yield is about 10 tons of dry mannter / year. Similar yields can be achieved with other fast-growing trees such as poplar.

² From Возможности использования альтернативных источников энергии в Республике Беларусь, 2004

³ 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.

We expect the development of energy plantations to take off after 2020 and that the area then will be increased with 100 km²/year until 2040 and then more until the full potential is used in 2050.

Geothermal energy

There are some geothermal reserves in Belarus, but the temperature is not so high, so we have not included the use of geothermal energy in this work.

Hydropower

The hydropower production was 80 TJ in 2000 (IEA statistics) which increased to 130 TJ in 2005. According to Belarus experts the potential is 10 PJ (2,8 Twh), and therefore we expect an expansion of hydropower to use 2% of the potential in 2010 and 15% in 2020 [is it realistic?], can we use more?]

Efficiency Potentials

Official estimates from the Belarus Ministry of Energy are that energy savings of 4.6 Mtoe is possible until 2010 equal to 19% of the primary energy consumption.

For the vision is used 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). 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 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 use and road transport (cars, buses, freight) to reach a factor 4 efficiency increase 2000 – 2050:

- 2000 – 2010 5% in total
- 2010-2020: 2%/year
- 2020-2030: 3%/year
- 2030-2040: 4%/year
- 2040-2050: 4%/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 is expected implementation of technologies to regain brake-energy from vehicles.

In the industry sector, the efficiency increase is not expected before 2010 neither for heat & fuel nor for electricity use. This is in line with the increase of consumption 2000-2005 and the expectation of stable production.

For agriculture, construction, rail and water transport the following efficiency increases are included until 2050: 50% for agriculture and 50% for construction, 65% for rail transport (partly achieved with electrification from currently 25%), 50% for pipeline transport, 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 Belarus total heat consumption (fuel and district heating) of dwellings was 276 PJ in 2000 of which 49% was district heating. This demand has declined until 2005 to 223 PJ (19%) with district heating declining in share to 46%. At the same time there are built 4 mill. m² of dwellings a year of which we assume 90% will increase dwelling area and the rest replace demolition. With about 180 mill. m² of dwellings, the increase of area will be 20% in the decade 2000 – 2010. If this is combined with the reduction of energy with 19% 2000 - 2005 (according to IEA statistics) after which we assume the situation not to change until 2010, the increase of energy efficiency is 32% in the decade 2000 – 2010. After 2010 we assume continued efforts for energy efficiency with further implementation of building regulation and increasing energy prices, leading to an increase of building efficiency of 2%/year. This is similar to the assumptions for visions for Western Europe. This gives the following specific heat demand and heating system efficiencies of dwellings, compared with 2000:

	Specific heat demand
2000	100%
2010	68%
2020	71%
2030	61%
2040	53%
2050	45%

Belarus heat consumption of service sector (fuel and district heating) has increased a factor 5 from 2000 (10 PJ) to 2005 (59 PJ) according to IEA statistics. We assume that this is a statistical error in the IEA statistics.

We assume that the IEA-2005 figures are more reliable than the 2000 figures, so we include the reported increase in the activity of the sector, while we include that the efficiency has not changed. After 2010 we expect the same reduction than in housing, but with a higher starting point. This gives the following specific heat demand and heating system efficiencies of service sector buildings:

	Specific heat demand
2000	100%
2010	100%
2020	91%
2030	81%
2040	73%
2050	65%

Efficiency in Energy Supply

In an official estimation from Belarus Ministry of Energy, efficiency in the energy supply, in particular in CHP plants can save 0.9 Mtoe (38 PJ) until 2010.

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 electricity efficiency in the CHP plants of 15% in 2000 is expected increases already in 2010 with renovation of power plants, in line with official estimates.

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

Power plant efficiencies	2000	2010	2020	2030	2040 and later
Electric	15,30%/39,4%*	20,00%/39,4%*	35%/39,4%*	45,00%	47%/55%*
Heat	53,60%	53,00%	40,00%	35,00%	33%/0
Total	68,90%	73,00%	75,00%	80,00%	80,00%

* Second value 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), 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.) 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% load	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 2030 (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 of the CHP plants are below the plant characteristics as the plants will not run with full heat production during the whole year.

Also the efficiencies of the electric grid is expected to increase. We expect that the electric grid losses will be reduced from 14% of production in 2000 to 7% in 2030 and then remain on that level. The losses in heat grid was 7% of production in 2000 according to IEA statistics. We do not expect these losses to change.

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 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):

Dwelling area is increasing with construction of 4 mill. m² of new dwellings every year. We assume that 90% of this is actual increase in dwelling area and the rest replaces demolition. There are official plans to increase construction of dwellings to 10 mill. m²/year, but given the economic crisis we do not expect it to happen soon, and given the need to replace panel houses, we find that an increase of dwellings will replace more demolition rather than leading to a faster increase of dwellings. The dwelling area is low in Belarus compared with many other countries, so we expect the increase to continue until 2050. The development is expected to follow this path compared with 2000, where there were about 180 mill. m² of dwellings:

2000: 100%

2010: 120%

2020: 140%

2030: 160%

2040: 180%

2050: 200%

The increase of service sector is faster than dwellings, and we expect that this will lead to an increase of 17% 2010-2020. From 2000 to 2010 is included the 6 times increase in IEA statistics from 2000 to 2005. We expect to be a statistical error, but we include it as we expect the 2005 data to be more reliable than the 2000 data. This gives the following development of service sector area for the vision:

2000: 100%

2010: 600% (increase from 2000 based on statistical error)

2020: 700%

2030: 750%

2040: 800%

2050: 180%

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

Construction is expected to double 2000 – 2010, so we assume that the sector's energy demand doubles as well. It is then expected to remain constant on the current higher level.

Electricity:

Household Sector: we expect household use of electric appliances to increase 20% more than the increase in floor space, with half of this additional increased achieved in 2010. This will lead to an energy service level in 2050 of 220% of the 2000 level.

Service sector: The sector increased its electricity consumption with 8% from 2000 to 2005. We expect this to continue, leading to an activity level in 2010 of 120% of the 2000 level and then increase with floor area (from heating), leading to a level in 2050 of 170% of the 2000 level.

Industry and farming: We assume constant activity during the period.

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

Transport:

Passenger is increasing in Belarus, and we expect the number to increase 38% from 2000 to 2010 and that the growth will continue until 2030 where there will be twice as many cars as in 2000. Then we expect the number to be constant and that further increase in mobility will be with public transport.

Public transport is increasing slowly, and we expect the increase to lead to 5% increase in train use and 10% in bus use from 2000 to 2010. Then we expect the increase to accelerate, leading to 19% of the 2000 level in 2020 and 82% in 2030. In 2040 and later we expect that the train use will be 3 times the 2000 level and bus use 2.5 times.

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

	Cars	Train	Buses etc.
2000	100%	100%	100%
2010	138%	105%	110%
2020	191%	119%	119%
2030	200%	182%	182%
2040	200%	300%	250%
2050	200%	300%	250%

Air transport not included in this vision.

Freight transport was not growing in Belarus in the period 2000 – 2005 as it did in many other Central European countries, mainly because of less transit transport. Anyway we expect a 10% increase 2000 – 2010 and then a continued growth. This gives the following freight transport relative to 2000:

2000: 100%
2010: 110%
2020: 120%

2030: 130%
2040: 140%
2050: 150%

No modal shift is expected in freight transport, all transport modes are expected to have the same increase with the exception of pipeline transport:

Pipeline use: growing 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.

[Fuel shift in transport is starting with introduction of biofuels in transport, initially using the full potential for road transport in 2020, covering XX% of road transport fuels.]

In 2030 we expect that railways will be more electrified, covering 40% of rail transport (from 27% until 2020) while we also expect that electricity will cover 15% 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 80% and 35%. We expect that hydrogen will cover 2% of road transport needs.

In 2050 we expect that the railways will be fully electrified while road transport will be covered by 78% electricity, 20% hydrogen, and the rest biofuels and a bit fossil fuels.

Fossil fuels and Imports

The production of gas and oil is expected to continue until 2030 and then phase out with declining resources until 2040. The peat production of 78 PJ in 2000 decreased to 75 PJ in 2005 and is expected to continue until 2020 and gradually phased out as demand is taken over by renewable energy.

Fossil fuels that are not produced in the country will be imported; but with the conversion to renewable energy, the import of fossil fuel will be reduced gradually to almost nothing in 2050.

The electricity import will be reduced, in the current version of the vision from 26 PJ in 2000 to 13 PJ in 2010 and nothing in 2020 (it was already reduced from 2000 to 2005). After 2040 the import is expected to increase again to 11 PJ in 2050.

Energy storages and Heat Pumps

Higher 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 5% raising to 14% in 2030 and further to 27% in 2050.

To cope with this the regulation capacity of the other power plants and using of flexible energy consumption can be used.

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

- heat pumps in the district heating systems that can produce heat when there is high electricity production compared with supply. In this vision is included heat pumps from 2040 and in 2050 they are expected to cover 50% of the district heating supply.

For the CHP plants is needed daily/weekly heat storages (water tanks) to de-couple electricity and heat deliveries. The heat pumps mentioned above should also be coupled with these storages that are integrated in the district heating systems.

There might be need for a few seasonal storages for solar heating after 2040 as the limits for use of solar heating without these storages is reached.

About this note

This note was developed by Gunnar Boye Olesen, INFORSE-Europe in cooperation with Evgenij Shirokov, MD-IAE for the Vision2050 for Belarus. Read more about the vision for Belarus and for other countries at www.inforse.org/europe. Please send comments to ove@inforse.org.