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Clean Energy Technology Assessment Methodology Pilot Study

Belarus

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Sonja Lekovic

INTERNATIONAL ENERGY AGENCY

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Foreword

I am pleased to present the results of the International Energy Agency (IEA) Clean Energy Technology Assessment Methodology (CETAM) pilot study for Belarus, alongside two other pilot studies conducted in Morocco and Kazakhstan, published separately.

The IEA is at the forefront of clean energy – the Agency is modernising by increasing activities in clean-energy technology and innovation, while strengthening ties with emerging economies and assisting them towards a cleaner future. Most recently in June 2016, the IEA became a new home for the Clean Energy Ministerial, a multinational forum on accelerating the global transition to clean energy.

The benefits of increasing the deployment of clean energy technologies range from reducing climate change to strengthening energy security and increasing economic productivity. However, increasing the uptake of clean energy technologies requires a strong enabling environment, including supportive policies and stable sources of finance. Equally important are tools for policy makers and investors to assess markets for clean energy technologies, empowering them to make informed decisions on technology policies and investments. To this end, the IEA has developed CETAM as a tool for decision makers to assess and monitor clean energy technology markets in the Early Transition Countries (ETCs)[1] and Southern and Eastern Mediterranean (SEMED)[2] region, as well as in other developing and emerging economies.

Belarus has provided an interesting case study for piloting CETAM due to its solid renewables and energy efficiency potential and a comparatively comprehensive data collection system. An ETC, Belarus has made momentous changes to its economy since its independence, albeit the state maintains a significant role in most sectors, including the energy system. Through strong relationships with other members of the Eurasian Economic Union, Belarus continues to have access to affordable fossil fuels (mainly gas) which has delayed developments of domestic energy sources. This report shows that Belarus could improve security of supply and sustainability through further development of its largest domestic energy resources - renewables.

On the energy efficiency side, applying CETAM shows that Belarus has made significant progress in curbing energy demand growth and improving efficiency; however, like many countries in the region, reliance on ageing infrastructure means that significant opportunities for further efficiency improvements remain. By deploying energy efficiency technologies, Belarus has an opportunity to “leapfrog” energy-intensive phases of development due to the availability of affordable improved technologies.

It is my hope that the findings of this study will encourage more countries to apply CETAM, so that decision makers can gain a clearer picture of the untapped renewable energy and energy efficiency potential and use this knowledge to accelerate the deployment of clean energy technologies for sustainable development.

Mr. Paul Simons

Deputy Executive Director

International Energy Agency

[1] Under FINTECC (Finance and Technology Transfer Centre for Climate Change), the ETCs are: Armenia, Azerbaijan, Belarus, Georgia, Kyrgyz Republic, Moldova, Mongolia, Tajikistan, Turkmenistan and Uzbekistan. The IEA-European Bank for Reconstruction and Development (EBRD) collaboration also considers Kazakhstan as a reference country within this grouping.

[2] For the EBRD, and for the purposes of the IEA-EBRD collaboration, SEMED refers to: Egypt, Jordan, Morocco and Tunisia.

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The IEA preparation of this Partner Country Series Paper was conducted under the auspices of collaboration with the Finance and Technology Transfer Centre for Climate Change (FINTECC) of the European Bank for Reconstruction and Development (EBRD). Launched in 2013, EBRD FINTECC, funded by the Global Environment Facility (GEF), is designed to support climate technology transfer in the ETC and in SEMED region through a combination of policy dialogue activities, technical assistance and EBRD financing blended with incentives. This IEA-EBRD collaboration is aimed at addressing the information gap related to the market penetration of climate technologies[3] in the ETC and SEMED regions.

The GEF is a partnership for international co-operation where 183 countries work together with international institutions, civil society organisations and the private sector, to address global environmental issues. Since its establishment in 1991, the GEF has provided 13.5 billion US dollars (USD) in grants and leveraged USD 65 billion in co-financing for 3 900 projects in more than 165 developing countries.

The IEA wishes to convey its sincere thanks to the EBRD for their financial support of the project via the FINTECC programme, supported by the GEF, and via the EBRD Special Shareholders Fund.

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[3] In the framework of FINTECC, "climate technologies" concern technologies that can assist climate change mitigation and/or climate change adaptation. The IEA collaboration with the EBRD focuses on energy efficiency and renewable energy technologies ("EE&RET"). In parallel, the EBRD is collaborating with the Food and Agriculture Organization (FAO) on climate technologies with a focus on the agrifood and water sectors.

Executive summary

Belarus gained independence from the Soviet Union more than 20 years ago, and has developed on a somewhat unique path since. Through manufacturing and export-driven development, economic growth has been growing steadily since the mid-1990s, with a stable rise in the standard of living. Belarus has also benefited from access to inexpensive gas imports from Russia, reflected in the high use of gas in both electricity and heat generation. However, despite these factors that tend to lead to growing energy demand, Belarus has decoupled economic growth from energy supply over the past decade, owing to structural changes in the economy and demand management programmes.

The main energy sector challenges for Belarus are echoed around the world – the need to diversify its energy mix and improve security while reducing greenhouse gases (GHGs). For Belarus this means reducing reliance on imported gas through an increase in the domestic production of low-emissions energy sources, including both nuclear and renewables. Additionally, despite already decoupling energy demand from economic growth, energy efficiency potential for curbing future demand growth remains vast, as most of the existing energy infrastructure is from the Soviet era, particularly in district heating and the building stock.

In order to assess the market potential for clean energy technologies and current levels of deployment in Belarus, the IEA has piloted the IEA Clean Energy Technology Assessment Methodology (CETAM). CETAM is designed to provide clear, transparent information about clean energy technology markets and to assist countries and investors to identify the most promising clean energy technologies for policy support and investment, as well as establish metrics for tracking their deployment over time. Below is the summary of outcomes of the study for renewable energy technologies and energy efficiency technologies in Belarus.

Renewable energy technologies

Belarus is estimated to have approximately 60 million tonnes of oil-equivalent (Mtoe) of renewable energy potential, which is more than three times the current level of energy demand. The country is rich in biomass resources on account of plentiful forest land, while potential for solar photovoltaics (PV), wind and biogas is also reasonable. Hydropower resources are limited and mostly already utilised, while large-scale concentrated solar power (CSP) is not viable in Belarus.

To reach its strategic priorities of reducing heavy reliance on imported gas and cutting GHG emissions, the country is, on the one hand, focused on the development of a nuclear reactor that would provide 30% of electricity generation by early 2020s. On the other hand, renewables remain a priority for the Belarusian government as a way of diversifying the energy mix and strengthening energy security.

Currently Belarus has approximately 6 gigawatts (GW) of renewable power generation capacity, mainly in biomass heat generation with marginal wind, solar and biogas installations. Renewables account for around 5.5% of total primary energy supply (TPES) and only about 1.1% of electricity generation (the remainder is nearly all from gas). Biomass represents around 8% of total heat generation in Belarus.

The government plans to increase renewables electricity generation from 0.3 gigawatt hours (GWh) in 2014 to 2.6 GWh by 2035. Substantial additional investment would be required to achieve this target, and deployment will be dependent on the enabling environment for renewables technologies. A range of relatively generous feed-in tariffs (FITs) is available at present; however, existing quotas to 2018 that restrict the number of grid-connected renewable energy generators are a significant deterrent to greater investment. This is particularly the case for foreign investors who are unfamiliar with the investment climate in Belarus. More positively, the government is easing administrative requirements and improving legislative transparency, in order to improve the investment climate.

Energy efficiency technologies

Energy efficiency potential in Belarus is vast due to ageing infrastructure and insufficient investment in modernisation over the past two decades. This is particularly true for the residential sector, which accounts for a quarter of total final consumption (TFC). Industry and the transport sector are also large consumers, albeit with different consumption patterns – while structural economic change has led to a decline in industrial activity and energy demand, growing living standards have driven strong growth in demand for vehicles and energy consumption in the transport sector.

This pilot study has resulted in the identification of a range of priority energy efficiency technologies for deployment in key sectors (residential, transport and industry). The current market penetration for the majority of the priority technologies is estimated at less than 50%, meaning significant deployment opportunities are likely in the future.

With the strong government dedication to curbing energy demand growth and modernisation of energy supply, Belarus is well placed to implement targeted energy efficiency programmes and measures in all sectors of the economy. In order to attract sufficient investment in the sector, the country would benefit from continuing to develop detailed energy efficiency indicators for monitoring progress, as well as from improved legislation and market conditions for the development of ESCOs.

Introduction

Project overview

Renewable energy technologies (RETs) and energy efficiency technologies (EETs), referred to from this point on as "clean energy technologies",[4] have many well-documented benefits. Clean energy technologies are important for improving energy access, energy security and economic productivity, and have a host of other co-benefits. With the majority of GHG emissions generated by energy, shifting to renewable, low-carbon energy sources and using energy efficiently are vital to mitigating anthropogenic climate change.

Despite these benefits, deployment has been slow in some regions, even where there are plentiful renewable energy resources and energy efficiency opportunities. Such is the case in certain Southern and Eastern Mediterranean (SEMED) countries[5] and Early Transition Countries[6] (ETCs) of the Black Sea-Caspian region. While a myriad of reasons can be identified for the relatively low deployment of clean energy technologies in these countries, broadly speaking, analysis has shown that policies that directly support clean energy technologies, and the wider "enabling environment" in which these policies operate, are underdeveloped (IEA, 2015c).

While there is a general understanding that deployment of clean energy technology in these regions has been low, detailed information tends to be a lacking on exactly which technologies have been deployed in which sectors and whether the market conditions are such that uptake could be increased. This presents a potential barrier to implementing effective policies and increasing public and private finance; it is difficult to make targeted policy and investment decisions without detailed information on the existing market penetration of clean energy technologies and the potential for increased deployment.

To help fill the information gaps described above, the EBRD has partnered with the IEA to deliver a project under the EBRD FINTECC. Launched in 2013 and funded by the Global Environment Facility, FINTECC is designed to support climate technology[7] transfer in the ETCs and SEMED countries through a combination of policy dialogue activities, technical assistance and EBRD finance blended with incentives.

The IEA-EBRD project has two main work streams:

1) **Policy dialogue for needs assessment**: to review and establish the necessary policy instruments to support market penetration of climate technologies. The primary output of this work stream was the IEA Insights Paper, *Enabling Renewable Energy and Energy Efficiency Technologies: Opportunities in Eastern Europe, Caucus, Central Asia, Southern and Eastern Mediterranean* (IEA, 2015c).

[4] For the purposes of this paper, "clean energy technologies" refer to RETs and demand-side EETs. It excludes analysis of other technologies that can be used to reduce carbon emissions on the supply side, such as nuclear energy or carbon capture and storage, and technologies to increase the energy efficiency of energy production, transmission and distribution.

[5] For the EBRD, and for the purposes of the IEA-EBRD collaboration, SEMED refers to: Egypt, Jordan, Morocco and Tunisia.

[6] Under FINTECC (Finance and Technology Transfer Centre for Climate Change), the ETCs are: Armenia, Azerbaijan, Belarus, Georgia, Kyrgyz Republic, Moldova, Mongolia, Tajikistan, Turkmenistan and Uzbekistan. The IEA-European Bank for Reconstruction and Development (EBRD) collaboration also considers Kazakhstan as a reference country within this grouping.

[7] In the framework of FINTECC, "climate technologies" concern technologies that can assist climate change mitigation and/or climate change adaptation. The IEA collaboration with the EBRD focuses on EETs and RETs, referred to collectively as "clean energy technologies" (refer to footnote 4 above). In parallel, the EBRD is collaborating with the Food and Agriculture Organization on climate technologies with a focus on the agrifood and water sectors.

2) **Methodology for market assessment and monitoring:** to assess and monitor the market conditions for clean energy technologies. The first output of this work stream will be the IEA Insights Paper, *The Clean Energy Technology Assessment Methodology: A Methodology for Assessing Renewable Energy and Energy Efficiency Technology Markets* (IEA, 2016). The second major output of this work stream is a series of three pilot studies to test the methodology, of which the results of one pilot study are presented here.

Structure of this study

The remainder of this report is structured as follows. The rest of the introductory section provides a brief overview of the CETAM before outlining the purpose of the three pilot studies. In the following chapters, the results of the Belarus pilot study are presented, which include:

- A general overview of the country, including key elements of its existing energy profile.
- Results of the pilot study for RETs.
- Results of the pilot study for EETs.

Finally, closing remarks are provided at the end of the paper, summarising key findings from the pilot studies that could inform future applications of CETAM.

CETAM

CETAM is designed to provide clear, transparent information about clean energy technology markets in the SEMED and ETC regions. Its goal is to assist the EBRD and others to identify the most promising technologies for policy support and investment. It is based on previous IEA work on indicators and technology assessments and builds on other evaluation frameworks as appropriate. The methodology takes into account potential challenges related to data availability and consistency within the ETC and SEMED regions.

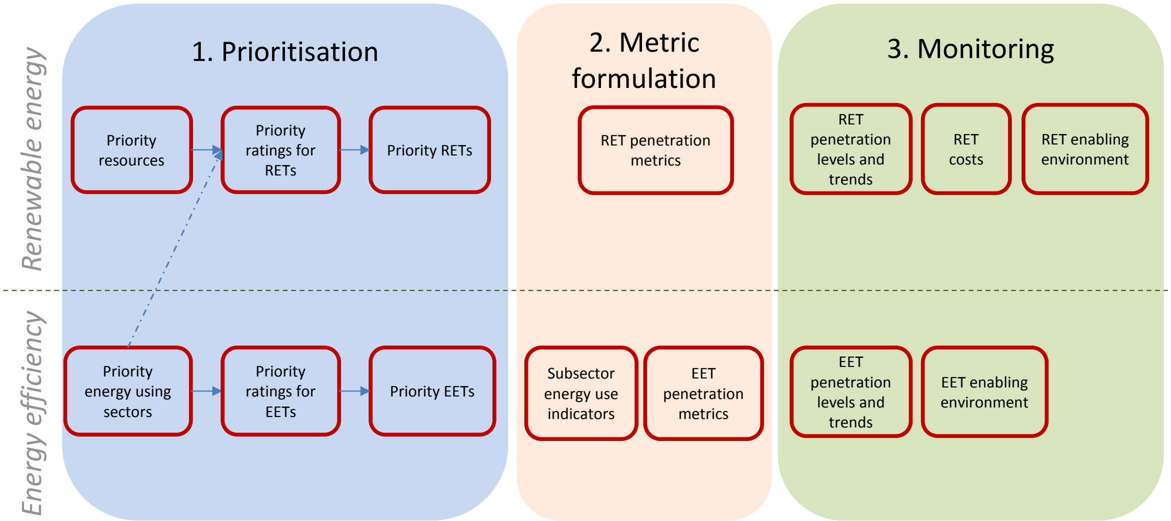
The primary users of CETAM will be the EBRD, which intends to use it as one input to inform assessment of RET and EET investment opportunities in the SEMED and ETC regions, and policy makers in the two regions, who could use it to track progress toward achieving clean energy technology deployment targets and inform policy formulation.

The methodology focuses on the energy supply and industrial, buildings and transport demand sectors, and is complemented by work being carried out by the Food and Agriculture Organization (FAO) in conjunction with the EBRD on the regionally important agro-industry sector. The methodology's outputs include:

- An assessment of priority clean energy technologies.
- Metrics for measuring the market penetration and impact of the above technologies on energy supply and demand.
- A high-level qualitative assessment of the enabling environment for priority clean energy technologies.

Key steps and outputs at each step are described in Figure 1 below.

Figure 1 • Key steps and outputs of the methodology



A full explanation of the methodology can be found in the IEA Insights Paper, *The Clean Energy Technology Assessment Methodology: A Methodology for Assessing Renewable Energy and Energy Efficiency Technology Markets* (IEA, 2016).

The pilot studies

CETAM has been developed in consultation with representatives from ETCs and the SEMED region to help ensure it is applicable in the two regions.[8] To further test the methodology's regional applicability, pilot studies were carried out in Belarus, Kazakhstan and Morocco. The aims of the pilot studies are to:

- Test the methodology in the field to ensure it is applicable to the two regions and gather information to inform the final design of the methodology.
- Provide the EBRD and the three pilot countries with useful assessments of clean energy technology penetration and market conditions, which could inform future policy design and investment.

These countries were selected as pilot countries based on discussions with the EBRD and representatives from the countries themselves. Key factors contributing to their selection included a strong interest in deploying renewable energy and EETs and the relatively good availability of data.

Data availability was of particular importance given the short timeframe available for conducting the pilot studies, and the IEA team acknowledges that data availability in the pilot countries may not be representative of the region as a whole. In a real world application, undertaking all steps of the methodology may require several months, if not longer, depending on the availability of information and data.

The IEA team conducted two missions to Belarus to meet with relevant stakeholders and gather necessary data. In addition, throughout 2015-16, data and information were shared electronically, which facilitated the successful implementation of the pilot studies within an accelerated timeframe.

[8] On 16 June 2015, the IEA held workshops on the draft methodology in Istanbul with representatives from ETCs and SEMED countries. Feedback from these workshops has been considered during the methodology's development.

While information on RET penetration is generally comparatively easy to obtain in most countries, EET penetration is very difficult to gauge, as a diverse range of EETs are spread across a large number of end-use sectors. To overcome this issue, the IEA provided pilot country counterparts with lists of "best-practice" EETs for each sub-sector, and asked in-country experts to prioritise these technologies and estimate their market penetration, using CETAM's EET prioritisation screening tool. The results are found at Annex A of this report.

The reader should note that for EETs, only Step 1 of CETAM (prioritisation) has been applied in full under this pilot study. Steps 2 and 3 are applied to *one* priority technology, as a means of demonstrating these CETAM steps. In the case of Belarus, these steps were applied to TRV and HCA retrofit packages. This decision was made for pragmatic reasons: the time required to analyse the penetration and market conditions, and establish metrics and monitoring systems, for all priority EETs within even one sub-sector would require resources well beyond the scope of this study.

Country overview

The Republic of Belarus (Belarus) is a landlocked country in Eastern Europe, bordered by Russia to the northeast, Ukraine to the south, Poland to the west, and Lithuania and Latvia to the northwest. Belarus covers an area of 207 595 square kilometres (km^2) (40% of which is forested) with 9.5 million inhabitants. Minsk, the largest city, is the national capital and home to about 20% of the population, the majority of which live in urban areas.

Despite a lack of natural resources and the economic downturn after the breakup of the Soviet Union, Belarus has achieved solid economic growth through manufacturing and exports, including machinery and equipment, mineral products, chemicals, metals and textiles. Real gross domestic product (GDP), measured in USD at 2010 prices, with purchasing power parity (PPP), was USD 160.7 billion in 2014. Real GDP grew at an annualised rate of 5.5% over the ten years to 2014, albeit with a slowdown since 2010 (2.4% per annum), owing largely to a drop in industrial activity.

Little structural reform has occurred in the country since its independence, and private and foreign investment remains relatively low (mainly in small enterprises). The energy sector is owned and operated by the government and the president holds the exclusive right to all strategic decisions. The electricity sector is operated by a single vertically integrated national energy company, BelEnergo, while the gas distribution sector is operated by BelTopGaz (excluding the main gas transit pipeline network that is operated by Gazprom TransGaz Belarus). The government believes that having control over the entire sector provides a secure and stable energy supply.

According to the World Bank's "ease of doing business" indicator, Belarus was ranked 44th among 189 countries in 2016. A high ranking on the ease of doing business index means the regulatory environment is more conducive to the start-up and operation of a local firm. This index averages the country's rankings on ten topics, made up of a variety of indicators, giving equal weight to each. Belarus has continuously improved its business environment over the years, increasing its ranking from 57/189 in 2014.

According to the Corruption Perceptions Index (CPI) prepared by Transparency International, which measures the level of perceived corruption in public systems, Belarus ranked 107th among 168 countries in 2015, with a score of 32. This is a relatively high score for perceived corruption in the country, as a score of 100 represents no corruption, although it is also improving over time.

Belarus is a member of the Eurasian Economic Union (EEU) that came into force on 1 January 2015. Other members include Russia, Kazakhstan, Armenia and Kyrgyzstan. The EEU permits free movement of goods, capital, services and people and provides for common transport, agriculture and energy policies, with provisions for a single currency and greater integration in the future. Belarus also participates in the European Commission's Eastern Partnership programmes and is involved in the implementation of a number of interstate and international treaties in the field of energy, including participation in the Commonwealth of Independent States (CIS) agreement on the co-ordination of interstate relations in the power sector, and the treaty on the parallel operation of power systems of the CIS.

Energy profile

Energy supply

Total Primary Energy Supply (TPES)[9] in Belarus was 27.7 Mtoe in 2014. This was 1.7% higher compared to 2013, albeit 9% lower than in 2012. The trend over the last decade has been a modest rise in energy supply: TPES was 3.6% higher in 2014 compared to 2004.

Natural gas and oil are the main fuels in the Belarusian energy mix, representing 90.6% of TPES in 2014. Natural gas accounted for 61.1% and oil for 29.5% of TPES in 2014, shares that have not changed significantly over the last decade. Coal and peat represented 1.8% and 1.2% of TPES respectively.

Renewable energy in Belarus accounted for 5.3% of TPES in 2014. Nearly all renewable energy is from biofuels and waste,[10] with negligible amounts of hydro, wind and solar PV. Energy from biofuels and waste has increased by 43.4% since 2004, which is significantly faster than the 3.6% growth in TPES. As such, biofuels and waste have increased their share of the energy mix over the past decade, up from 3.8% in 2004. Hydropower production has grown three-fold over the past decade, albeit remaining at very low levels. Wind power production began in 2012, while solar PV power started in 2014.

Given its modest natural resources, Belarus produces around 13% of its energy needs, with total energy production of 3.7 Mtoe in 2014. Belarus relies on imports from Russia to meet most of its energy needs. Belarus is also an important part of Russia's gas transit corridor to Western Europe. Matters related to natural gas transit, including the infrastructure, system operation, tariff structure and technical services are carried out under a bilateral agreement with Russia's Gazprom.

Energy demand

Total Final Consumption (TFC)[11] of energy was 20.4 Mtoe in 2014, made up of the residential sector (24.2%), industry (22.2%), transport (20.2%), non-energy use (16.4%),[12] the commercial and public services sector (11.4%), and agriculture, forestry and fishing (5.6%). The residential sector and industry have dominated final energy consumption in Belarus over the past decade, although both have seen demand fall during 2004-14: down by 3.1% in the residential sector and by 3.9% in industry. The strongest growth rate, a 61% increase from 2004 to 2014, has been in the transport sector, while consumption in the commercial/public services sector and in agricultural/forestry has increased by 16.8% and 19%, respectively. Non-energy use experienced the largest decline of 7.4% during 2004-14.

Belarus's energy intensity, measured as the ratio of TPES to real GDP, was 0.17 tonnes of oil equivalent (toe) per USD 1 000 GDP PPP (2010 prices) in 2014. Since 2004, energy intensity in Belarus has declined by 39.5%, down from 0.29 toe/USD 1 000 GDP PPP. Energy intensity has been declining since the mid-1990s due to strong economic growth and TPES that is growing at a

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[9] TPES is made up of production + imports - exports - international marine bunkers - international aviation bunkers ± stock changes. This equals the total supply of energy that is consumed domestically, either in transformation (for example, refining) or in final use.

[10] Biofuels and waste is an IEA definition of bioenergy and waste, including solid biofuels (biomass), liquid biofuels, biogases, municipal waste and industrial waste. This definition is used in IEA statistics only.

[11] TFC is the final consumption by end-users, i.e. in the form of electricity, heat, gas, oil products, etc. TFC excludes fuels used in electricity and heat generation and other energy industries (transformations) such as refining.

[12] Non-energy use covers those fuels that are used as raw materials in the different sectors and are not consumed as a fuel or transformed into another fuel.

comparatively slower rate due to structural economic reforms and demand management programmes.

Energy-related carbon dioxide emissions

Energy-related emissions of carbon dioxide (CO_2) totalled 58.3 million tonnes (Mt) in 2013, representing approximately 80% of total GHG emissions. The power generation sector accounts for 50.1% of energy-related CO_2 emissions, followed by transport (21.4%), manufacturing (9%), households (8.2%), energy industries other than power generation (6%), and the commercial and services sector including agriculture (5.3%). Energy-related CO_2 emissions in 2013 were 13.4% higher in 2013 compared to 2003, albeit 41.6% lower than in 1990.

Energy policy framework

The main priority of energy policy and strategy in Belarus is to provide a reliable and sustainable energy supply for the national economy, while reducing dependence on energy imports and improving the financial stability of the sector. Both renewable energy and energy efficiency have been identified as priorities to achieving these aims; however, most of the change in the energy sector will be due to a new planned nuclear power station, expected to become partially operational by 2020.

A new "Concept of Energy Security" came into force on 1 January 2016, the main energy policy document in Belarus. Policy objectives have remained the same compared to the previous policy document, including: an increase in the use of local fuels and a reduction in gas import dependency; expanding trade and regional co-operation; strengthening state control while allowing legal protection for smaller private companies; developing new technologies; and a reduction in the GDP energy intensity of Belarus.

The main strategic directions of the new Concept are as follows:

- reduction in import dependency and development of own energy resources
- diversification of import suppliers and increase in energy transit
- reduction in natural gas in the energy mix
- improved reliability through rehabilitation and modernisation, and increased oil reserves
- enhanced demand energy efficiency measures and reduced GDP energy intensity
- enhanced energy efficiency of production and distribution of energy
- improved customer affordability while phasing-out subsidies
- regional and global co-operation and trade/export development
- improved energy sector management.

On 1 March 2016, the government approved the "Comprehensive Development Plan for the Electricity Sector to 2025 and Beyond", allowing for integration of the planned nuclear power plant (NPP) and the necessary changes in the regulatory and technical framework. The plan also includes allowances for network rehabilitation and development, as well as tariff subsidy phase-out. On 6 April 2016, a new "Energy Efficiency and Energy Savings Plan for 2016-20" came into force.

The Belarusian government is also focusing on climate change and reducing GHG emissions. In 1992, Belarus joined the United Nations Framework Convention on Climate Change, ratifying the Kyoto Protocol in 2005. The "State Programme of Measures to Mitigate the Effects of Climate Change for 2013-20" sets a target to reduce GHG emissions by 8% in 2020 from 1990 levels, about 10 million tonnes of CO_2 equivalent ($MtCO_2$-eq). Measures include energy efficiency improvements, increases in forest areas, restoration of peat lands and improved legal and regulatory approaches. Belarus submitted its Intended Nationally Determined Contribution (INDC) to the 21st Conference of the Parties (COP21) in Paris in September 2015, with a pledge to reduce emissions by at least 28% in 2030 compared to 1990 (UNFCCC, 2015).

Results of the pilot study for RETs

Step 1: Prioritisation of RETs

1.1 Renewable resources

Information on renewable energy potential in Belarus is available from the National Programme on Local and Renewable Energy Development for 2011-15 and the publication *Potential for Renewable Energy Sources and Energy Efficiency* (Meerovskaya et al., 2014). Most of the renewable resource potential discussed below is from these sources, unless otherwise stated.

Bioenergy (biomass, biogas and biofuels)[13] is the largest renewable energy resource in Belarus. Wood resources (and therefore residues) are plentiful due to large forest areas while significant biogas resources exist from agricultural activities. Both resources remain largely untapped at present. Wind potential is also considered to be relatively large, up to 1 600 megawatts (MW), as are solar and geothermal. According to the National Agency of Investment and Privatisation website (National Agency of Investment and Privatisation, 2016), the estimated technical potential of renewable energy is around 60 Mtoe in Belarus, far higher than the current level of energy demand.

The following sections present a summary of all the potential renewable resources in Belarus, compared to European countries in certain cases.

Bioenergy

Belarus has a significant potential for biomass from wood residues as forests cover about 40% of the country's territory (9.5 million hectares), with around 50% mature solid biomass (wood).[14] Solid biomass resources from waste wood suitable for production of bioenergy include firewood, timber, wood residue and fast-growing grey alder. Solid biomass resources are estimated at 1.5 billion cubic metres (bcm) with annual growth of about 30.3 million cubic metres (mcm). Fast-growing plantation of grey alder account for around 18 mcm with about 1 mcm used as firewood. Solid biomass from waste wood is consumed in 7 heat plants and around 3 000 boilers. Existing production capacity of wood and waste wood fuels is estimated at 11.7 mcm annually (2.2 Mtoe) with around 10 mcm utilised at present. Figure 2 shows the availability of forest residues in Belarus. According to the National Programme on Local and Renewable Energy Development for 2011-15, energy potential from wood and wood processing waste is approximately 2.2 Mtoe per year. Potential from crop waste is estimated at 1.0 Mtoe per year, while potential from straw is about 0.7 Mtoe per year.

Belarus has vast potential for biogas, due to numerous professionally run large-scale animal farms (cattle, pig and poultry) as well as significant waste potential from households, crop farms, sewage treatment plants, municipal waste and food industry waste. The full potential for biogas is unknown, as is the potential of industrial and municipal waste. Table 1 exhibits 2007 statistics on the potential of biogas in Belarus, based on animal breeding waste (Greenworld.org, 2016).

[13] For the purpose of the paper, with the exception of reference to IEA statistics on "biofuels and waste", bioenergy resources are classified as biomass, biogas and biofuels. Biomass combustion represents burning organic material for fuel. Biogas is generated from anaerobic digestion of agricultural residues, manure and other sources of biomass. Biofuels include bioethanol and biodiesel. Bioethanol is made from a variety of feedstocks such as sugar cane, bagasse, sugar beet, grain and others, through the fermentation of sugars, distillation, dehydration and denaturing (optional). Biodiesel is made by chemically reacting lipids (e.g. vegetable oil, soybean oil, animal fat) with an alcohol producing fatty acid esters.

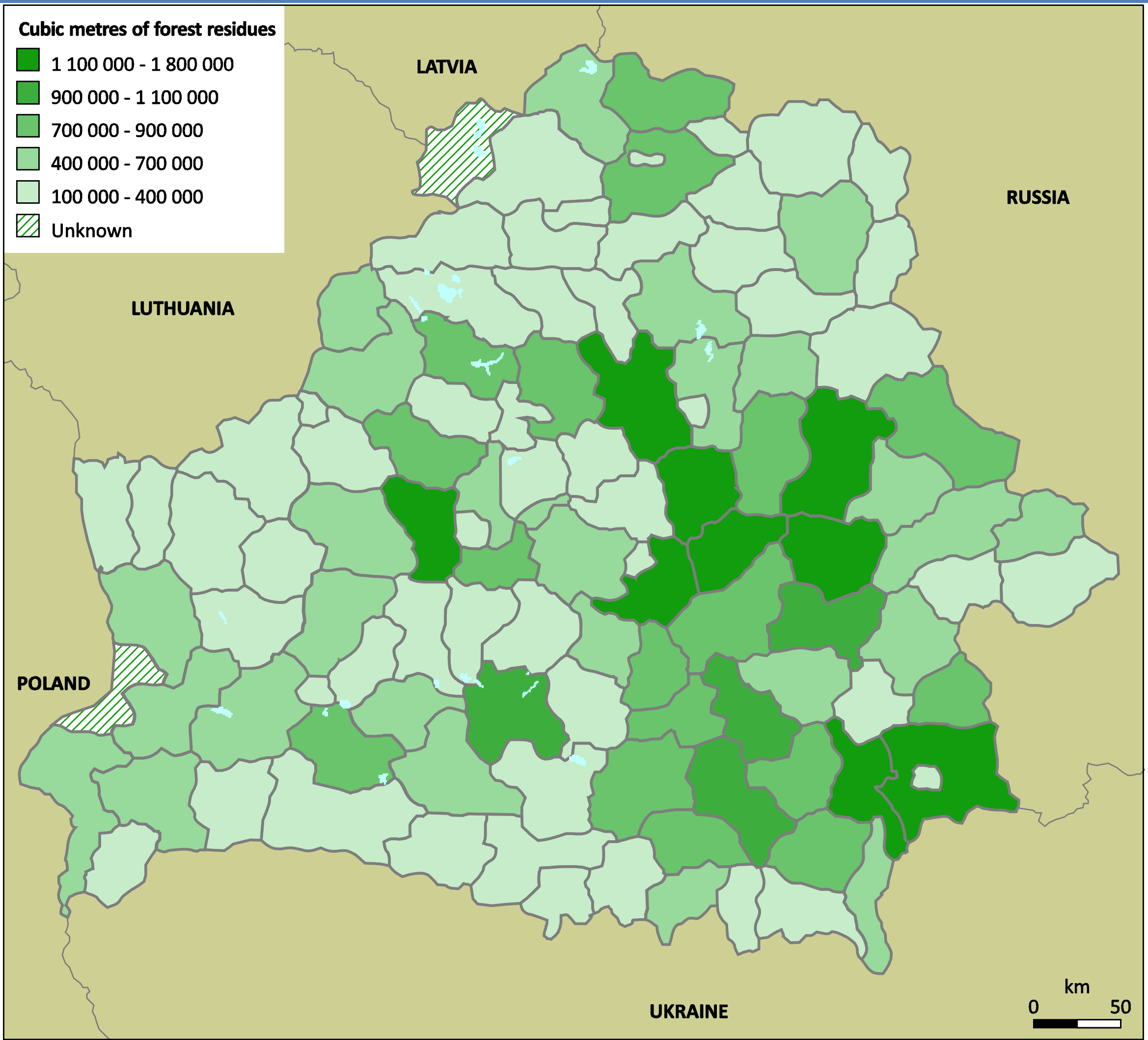
[14] Part of the forestry area may not be suitable for biomass such as pellets, given the potential contamination from the Chernobyl nuclear accident.

The table shows that for some 7.7 Mt of manure output per year, around 3.5 bcm/year (2.3 Mtoe/year) of biogas could be generated from it.

Preliminary studies of potential energy from wastewater treatment plants, carried out by the government, indicate that around 9.2 MW of heat is possible from the currently identified sites across the country. The potential of solid municipal waste is estimated at around 0.3 Mtoe/year.

Potential for biofuels (ethanol and biodiesel) production is considered to be plentiful, given the country's large agricultural land and activity, with most opportunities coming from sugar production, starch and the cellulose industry.

Figure 2 • Availability of forest residues in Belarus



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: Belarusian Web Portal on Renewable Energy (2015), www.re.energybel.by/en/renewable-energy-technologies/biomass-energy-overview/, accessed on 7 December.

Table 1 • Technical potential of biogas generation based on animal breeding waste, Belarus

	Store cattle	Milk cows	Pigs	Poultry	Total
Manure output, Mt/year	45.6	23.8	4.5	3.2	77.1
Biogas output, bcm/year	2.2	0.9	0.26	0.2	3.5

Source: Greenworld.org (2016), website, www.greenworld.org.ru/?q=ang_monografy_2, accessed on 3 May.

Hydropower

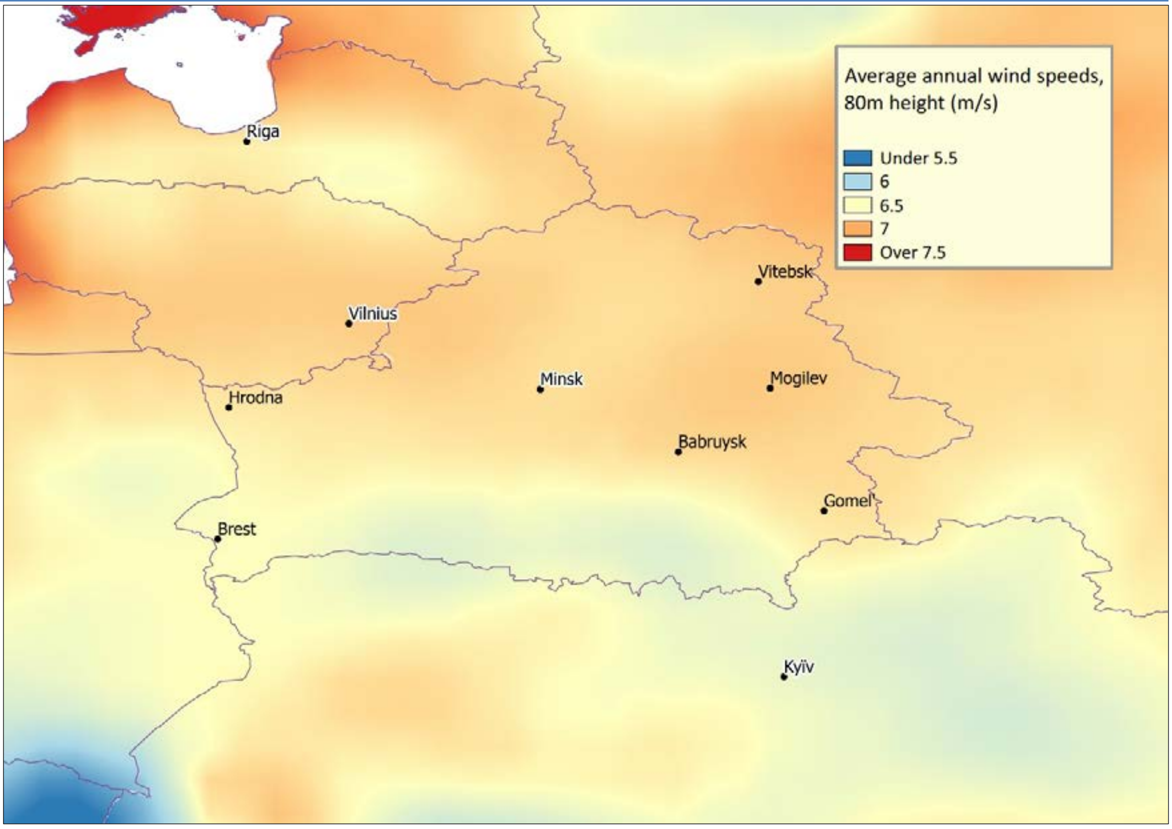
Hydropower resources in Belarus are considered to be scarce, albeit with opportunities for small hydro in the northern and central parts of the country (UNIDO and ICSHP, 2013). Potential hydropower in Belarus is estimated at 850 MW, including technically available potential of 520 MW and economically viable potential of 250 MW (0.44 Mtoe/year).

Wind

The energy potential of wind is estimated to be up to 1 600 MW, with 1 840 potential wind farm sites in three regions: Hrodna, Minsk and Mogilev. Figure 3 is a schematic map of Belarus showing the average wind speeds in metres per second for a wind energy plant with 2.5 MW capacity, at an altitude of 100 metres. Total wind potential is also estimated at 0.47 Mtoe/year. This is not a high quality resource, but still acceptable in certain places, given the recent development of low-wind speed turbines.

These potential estimates seem conservative given the wind regime. Modern wind technology developments have increased the scale of turbines (now with an average size of over 2 MW per turbine) and the energy yield, particularly at lower wind speed sites. It is therefore recommended that an updated estimate of wind potential should be undertaken, taking account of these developments and modern best practice in spacing and siting of turbines.

Figure 3 • Map of the average annual wind speeds in Belarus, at an altitude of 80 metres



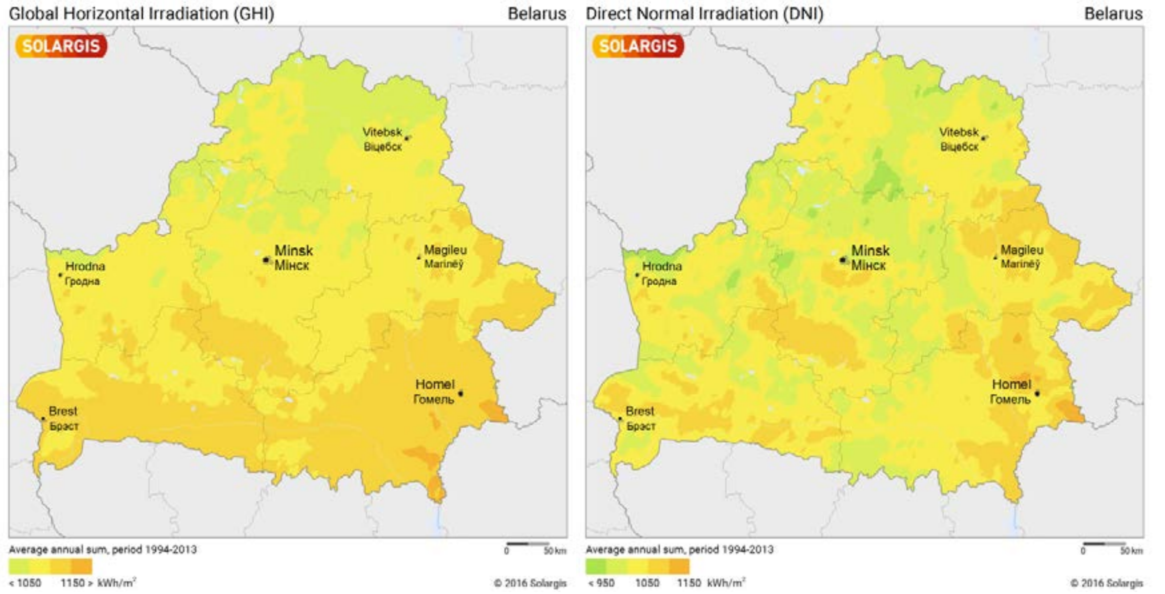
Disclaimer: This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries, and to the name of any territory, city or area.

Source: Rife, D. L., J. O. Pinto, A. J. Monaghan, C. A. Davis, and J. R. Hannan (2014), *NCAR Global Climate Four-Dimensional Data Assimilation (CFDDA) Hourly 40 km Reanalysis*, Research Data Archive at the National Center for Atmospheric Research, Computational and Information Systems Laboratory, dx.doi.org/10.5065/D6M32STK, accessed on 30 June.

Solar

While Belarus does not have a very favourable solar regime, its potential is significant, mainly in the south and southeast of the country. Figure 4 indicates the global horizontal irradiation (GHI) and direct normal irradiation (DNI) potential of Belarus. As the figure shows, most of Belarus only receives between 1 100 kilowatt hours per square metre (kWh/m^2) and 1 400 kWh/m^2 (GHI) and around 1 000 kWh/m^2 (DNI). This means that CSP generation is impractical, but that production by means of solar PV is possible. There is also the potential to use solar energy in solar water heaters and other systems for water heating and drying in agriculture, water heating and space heating in buildings, and low-temperature process heat in industry and services. Total solar potential is estimated at 49.7 Mtoe/year.

Figure 4 • Solar resource maps (GHI, left; DNI, right)



Disclaimer: This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries, and to the name of any territory, city or area.

Sources: Maps provided by Solargis.

Geothermal

Belarus's geothermal potential is relatively undiscovered, with only a few regions tested. Of the tested regions, the most promising geothermal energy potential lies in the Pripyat Trough (Gomel region) and the Podlasie-Brest Depression (Brest region), in dozens of abandoned deep wells (Zui, 2010). Other areas studied include the shallow sedimentary horizons in the western part of the country, while potential for low-enthalpy geothermal energy is believed to exist within the whole territory.

In February 2016, the first geothermal atlas of Belarus was published, consisting of around 50 detailed maps showing where renewable resources from geothermal wells can be used (Belteleradiocompany, 2016).

Table 2 summarises the resources and potential for renewable energy development in Belarus. The quality of resources is deemed to be significant, with the largest resources in bioenergy, albeit the country lacks detailed technical studies of the full potential of different renewables technologies. Available studies for hydro and wind offer some insight into the potential of the use of these renewables in energy production, while studies on the technical potential of bioenergy, solar and geothermal energy are not available in Belarus at present.

Table 2 • Resources and measured potential, Belarus

	Hydro	Biomass	Biogas	Biofuels	Wind	Solar	Geothermal
Resource quality	Low	High	High	High	Medium	Medium	Medium
Potential (Mtoe)	0.4	3.9	2.3	Unknown	0.5	49.7	Unknown

Source: Greenworld.org (2016), website, www.greenworld.org.ru/?q=ang_monografy_2, accessed on 3 May.

1.2 Likely costs of producing electricity

CETAM includes a procedure for estimating the likely costs of each of the main generating technologies, based on an analysis of global capital costs and typical operating parameters. These capital costs can then be adapted to prevailing local financing conditions, reflecting the typical cost of finance expressed as the weighted average cost of capital (WACC) and the likely local resource availability. (IEA [2016] contains details of this procedure and the underlying assumptions.)

Financing conditions in Belarus are affected by poorer international credit ratings and high inflation levels. It is therefore anticipated that the underlying cost of capital would be relatively high, at around 15%.

Analysis of the available resource data suggests using eight renewables classifications, which are then compatible with the likely benchmark generating costs shown in Table 3.

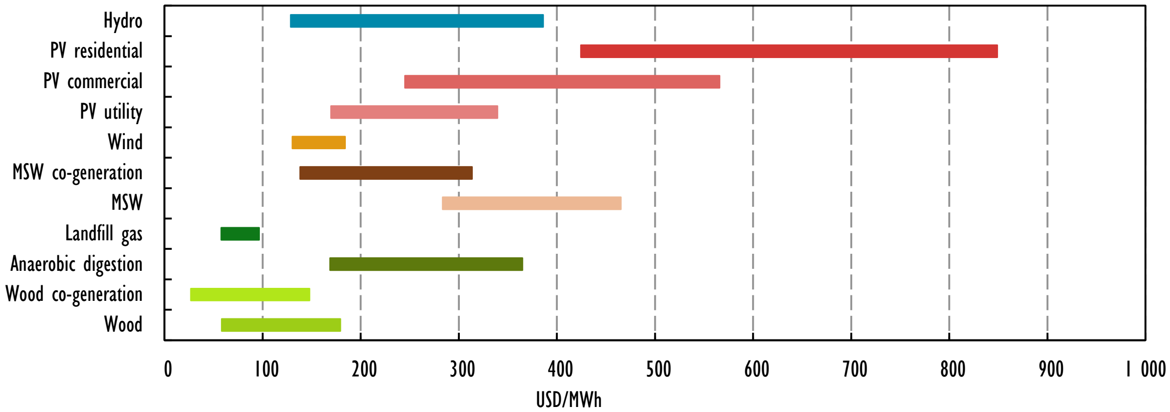
Table 3 • Likely cost range for renewable energy generation, Belarus

Category	Comment	Ranking	Likely range of costs, USD/MWh	
Wood and agricultural residues	Extensive forestry and agricultural materials available	Good to excellent	Electricity only	58-179
			Co-generation	27-148
Municipal solid waste (MSW)	No environmental legislation leading to enhanced gate fees for MSW	Poor	Electricity only	284-465
			Co-generation	138-314
Landfill gas		Good		58-96
Biogas (anaerobic digestion)	No environmental legislation leading to enhanced gate fees for waste disposal by anaerobic digestion	Poor	Electricity only	169-365
Wind	Some areas of moderate wind	Fair	Utility	130-184
Solar PV	Some areas of moderate solar	Fair	Utility	170-340
		Fair	Commercial	245-566
			Residential	424-849
CSP	Insufficient resources	n/a	n/a	n/a
Hydro	Some promising sites	Fair		129-386

Notes: Co-generation refers to the combined production of heat and power; MWh = megawatt hour; n/a = not applicable. Information on gate fees is sourced from European Environment Agency (2016).

The range of likely generating costs is shown in Figure 5.

Figure 5 • Indicative renewable energy generation costs, Belarus



1.3 Technology maturity and ambition

All technologies deployed in Belarus at present are mature and have commercial status, according to Table 6 in the Methodology paper (IEA, 2016a). The technology with the most mature local market is biomass, currently used mainly in heat generation. Belarus is still in the early the stages of deployment of wind, solar PV and biogas, although the technologies used in their development are considered to be mature and of international standards.

Belarus does not conduct significant research and development (R&D) in renewable technologies, focusing mostly on energy savings and efficiency. Under the latest Scientific and Technical Programme for Power Engineering and Energy Efficiency for 2011-15, R&D priorities in renewables included resource assessments and the use of industrial biogas and municipal waste, albeit without significant funding. Other areas of development include production of competitive equipment and instruments that increase energy efficiency and system reliability.

1.4 Strategic priorities

Belarus's demand for energy is growing due to moderate economic growth and modernisation of industry and households, while the country is almost fully reliant on imports for its energy needs. The government is committed to reducing import reliance through development of the country's own energy sources and curbing demand growth through energy efficiency measures. In order to reduce import reliance, one of its major strategic priorities is to reduce the share of gas in the energy mix and to diversify energy resources. Additionally, Belarus is committed to reducing GHGs by at least 28% in 2030 compared to 1990, according to its INDC submitted to COP21 in September 2015 (UNFCCC, 2015). This would allow an increase of approximately 15% compared to 2012 GHG levels.

Renewables could play an important role in meeting these priorities since the energy is all produced indigenously, and could contribute significantly to reducing import dependency, improve the balance of payments situation and improve energy security. Introduction of renewables could also reduce reliance on gas in all sectors of the economy, and diversify the energy mix. In addition, renewables offer significant opportunities to reduce GHG emissions, and could play an important role in meeting Belarusian INDC commitments.

At present however, the majority of energy source diversification is expected to be achieved through nuclear power development, with a share of only 9% of renewables envisaged by 2035. This indicates that while renewables will play a part in energy sector development, they are not the main priority for the government.

Under the new Concept on Energy Security, the strategic priorities of the Belarusian government and indicators measuring RET development (among others) are:

- Production of domestic sources up to 20% of TPES by 2035, from 14% in 2015.
- Renewables production up to 9% of TPES by 2035, from 5% in 2015.
- Share of dominant fuel in TPES (gas) down to 50% in 2035, from 60% in 2015.
- Ratio of total installed capacity of power plants to maximum actual load grid (reservations) down to 145% in 2035, from 160% in 2015.
- Share of the dominant energy source (gas) in the production of heat and electricity down to 50% by 2015 from 90% in 2015.

According to the Concept, electricity generation is estimated to increase from 34.5 terawatt hours (TWh) in 2015 to 43.8 TWh in 2035. Nuclear's share is expected to represent 41% of total generation in 2035, with renewables accounting for 6% (up from around 1% in 2015). Total generation from renewables is expected to increase from around 0.27 TWh in 2015 to 2.6 TWh in 2035, growing by a factor of 10 over the 20 years, which is an ambitious projection rather than a target. Heat production forecast figures are not available in the Concept.

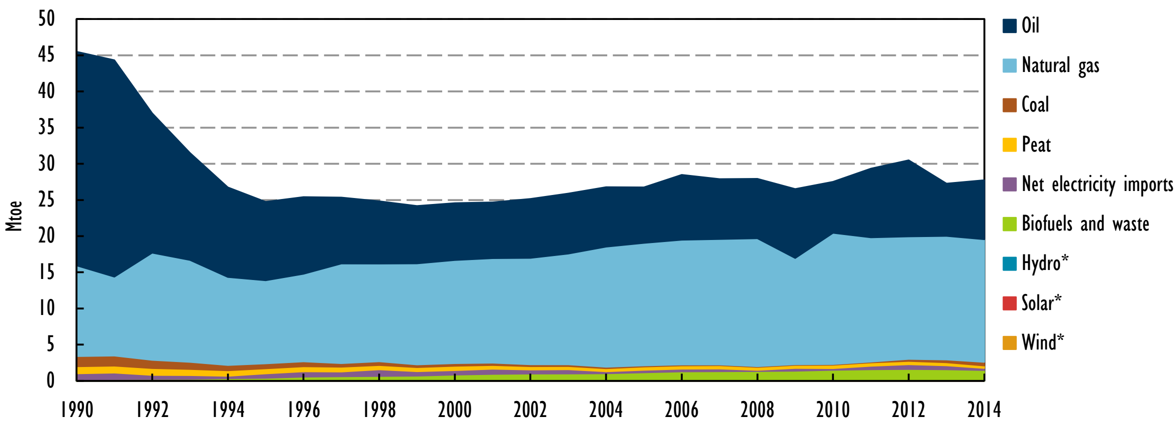
1.5 Market opportunities

Belarus is dependent on oil and gas for most of its energy needs. Natural gas represented 61.1% of TPES in 2014, with oil's share at 29.5%. Together, the two fuels account for 90% of domestic supply. This share has remained relatively unchanged since 2004 (Figure 6).

Other fuels in the energy mix in 2014 included biofuels and waste (5.3%), coal (1.8%), peat (1.2%), and negligible amounts of hydro, wind and solar PV. Net electricity imports represented 1% of total energy demand.

Belarusian production of crude oil and natural gas is limited, amounting to 5% of domestic consumption. Crude oil and gas reserves are low and production has not changed much over the years. Consequently, the country relies on crude oil and gas imports, all of which are sourced from Russia.

Figure 6 • TPES, Belarus, 1990-2014



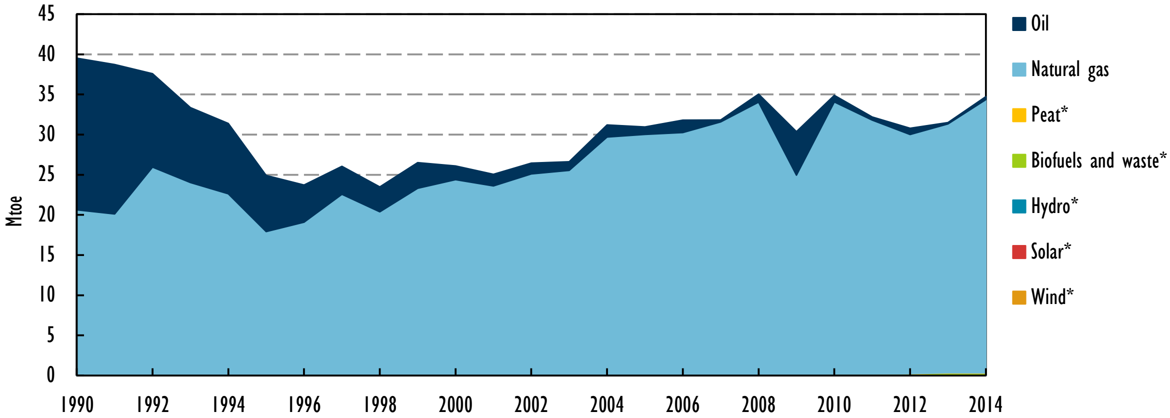
* Negligible.

Source: IEA (forthcoming), *Energy Balances of Non-OECD Countries 2016*, www.iea.org.

Electricity generation totalled 34.7 TWh in 2014 (Figure 7) and is fuelled mainly by natural gas. Natural gas represents 98% of total fuel use with the remainder coming from oil (1.1%), biofuels and waste (0.4%), hydro (0.3%) and peat (0.1%). Over the ten years to 2014, natural gas consumption in electricity generation has increased by 14.8%, with its share in total generation up from 95%. Electricity from peat and hydro is up by 550% and 267% over the same period, respectively, while oil use has declined by 75%.

According to the new Concept of Energy Security, electricity demand is expected to increase to around 44 TWh by 2035, to be sourced from domestic production. This would represent an increase in production of 38% over 22 years.

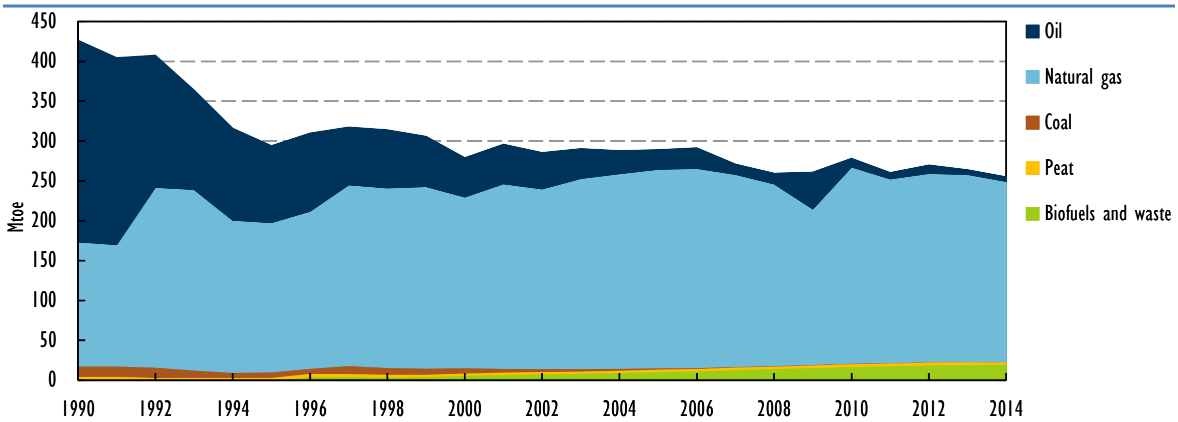
Figure 7 • Electricity generation by source, Belarus, 1990-2014



* Negligible.

Source: IEA (forthcoming), *Energy Balances of Non-OECD Countries 2016*, www.iea.org.

Figure 8 • Heat generation by source, Belarus, 1990-2014



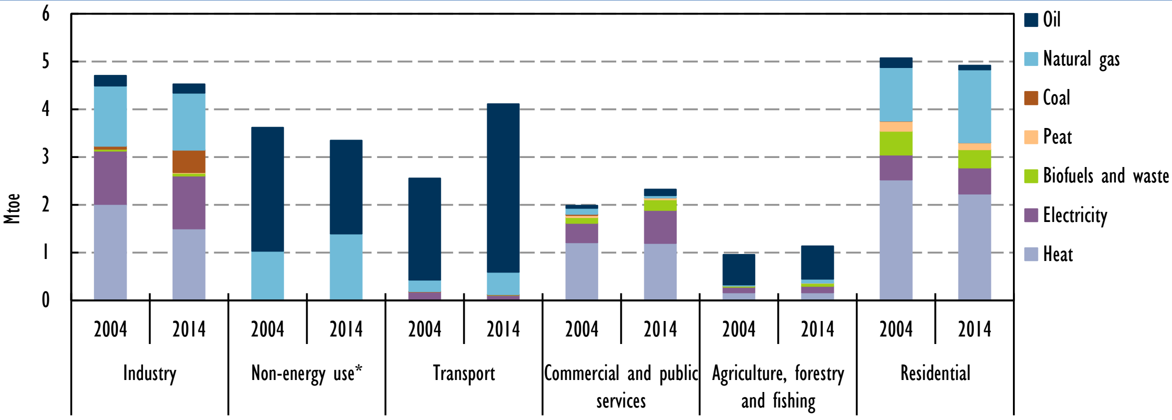
Source: IEA (forthcoming), *Energy Balances of Non-OECD Countries 2016*, www.iea.org.

Heat output totalled 254.9 petajoules (PJ) in 2014 (Figure 8) and was generated from gas (88.6%), biofuels and waste (8%), oil (2.1%), peat (1.3%) and some coal (less than 0.1%). Natural gas use in heat generation has fallen by 7.4% over the 10 years to 2014, albeit its share in generation has increased from 84.8% in 2004 as total heat production declined by 11.4% over the same period. Biofuels and waste and peat use grew by 105.3% and 11.8%, respectively, while the use of coal and oil is close to being phased out (declining by 97.7% and 81.1% during 2004-14, in that order).

The power generation sector consumes around 14% of TPES, with 6.3% in co-generation plants, 5.9% in electricity plants and 1.9% in heat plants. Around 9% of total energy supply in Belarus is consumed in the processing sector other than power generation – refineries and energy own-use – while 3.4% are losses.

Belarus's final energy consumption (energy use other than power generation and other processing) is dominated by the residential sector (24.2% of TFC), the industrial sector (22.2%) and transport (20.2%), while non-energy use, the commercial/public services sector, and agriculture, forestry and fishing account for 16.4%, 11.4% and 5.6%, respectively (Figure 9).

Figure 9 • TFC by sector by source, Belarus, 2004 and 2014



* Non-energy use covers those fuels that are used as raw materials in the different sectors and are not consumed as a fuel or transformed into another fuel.

Source: IEA (forthcoming), *Energy Balances of Non-OECD Countries 2016*, www.iea.org/statistics/.

Figure 9 shows that the main fuels used in industry are heat, electricity, natural gas and coal. Gas consumption in industry is often attributed to autonomous heat and electricity production. Biofuels and waste account for only around 1.2% of industry demand.

In the residential sector, heat is the largest source of energy, accounting for 45.3% of total demand. Gas represents 31%, however most of the heat comes from gas as well (see Figure 9). Electricity accounts for 11.2% of household use, with the remainder from biofuels and waste (7.7%), peat (2.9%) and oil (1.8%). The service sector is largely fuelled by heat (51.5%), electricity (29.9%) and biofuels and waste (9.4%). Agriculture, forestry and fishing consume mainly oil (61%), heat (14.5%) and electricity (11.8%). Non-energy use represents oil and natural gas used as raw materials.

The fastest-growing sector in Belarus is transport, increasing by 61% from 2004 to 2014, followed by agriculture, forestry and fishing (up by 19%) and the commercial and public services sector (up by 16.8%). Residential demand has contracted by 3.1% over the same period, while use by industry and non-energy use have declined by 3.9% and 7.4%, respectively.

Conclusions on market opportunities

Given the current energy mix and consumption trends in Belarus, and strategic priorities of reducing import dependence and reducing CO_2 emissions, the main market opportunities for renewables are:

- Grid-connected electricity: to provide a contribution to reducing gas use for power generation, so reducing import dependency and GHG emissions through expansion of the hydro, wind, biomass (wood and agricultural residues) and solar PV generation.
- Heating: to reduce the use of gas in heating applications in industry and buildings by increasing heat production from biomass sources (particularly wood residues), geothermal and solar heat.

- Transport: reducing transport fuel oil needs by encouraging production and use of indigenous bioethanol and biodiesel production.

1.6 Summary of priority RETs

The information above indicates strong strategic drivers for renewable energy development, mostly related to mitigating a high reliance on imported fossil fuels and a pledge to reduce GHGs.

Belarus has plentiful bioenergy resources, including wood and agricultural residues, and has potential for solar, wind and geothermal. However, despite its resource potential, given the likelihood of certain RETs being affordable, and the strategic drivers for using renewable energy, Belarus only has modest ambitions to deploy RETs, and has in fact imposed quotas on renewable electricity generation. The quotas specify the maximum contribution that each grid-connected renewable electricity source can make to Belarus's electricity supply, and have been imposed due to a fear that integrating intermittent renewables into the grid may pose challenges to stability of electricity supply.[15]

Due to these concerns, the government has expressed a preference for deploying RETs that it perceives as being relatively less risky in relation to grid integration. Biomass and biogas developments are a clear priority for the government, as expressed in their policy and development of renewables quotas and FITs.

Development of other renewables such as hydro and wind are supported; however the quotas for wind development, in particular, are quite low over the next few years and the previously planned programme of development has not resulted in a strong increase in capacity. Solar power development is mainly targeted through a planned distribution of solar heating units, while the first grid-connected solar installations began operations in 2014. Hydro potential is limited and the government has plans to develop close to its full potential by 2020.

Table 4 is a matrix ranking RETs against the main priority determinants, highlighting the priority technologies for the government of Belarus.

Table 4 • Matrix of priority indicators for RETs in Belarus

Technology	Resource	Strategic drivers	Market opportunities	Technology maturity	Likely cost	Priority score
Rooftop PV	★★	★★	★★★	★★★★	★	Ready for deployment
Large-scale solar PV	★★	★★	★★★	★★★★	★★	Need further evaluation
Large-scale CSP	n/a	n/a	n/a	★★★	n/a	No potential
Solar water heaters	★★	★★	★★★	★★★★	★★	Ready for deployment
Solar space heaters	★★	★★	★★	★★★	★★	Ready for deployment
Solar heat for industry / services	★★	★★	★★	★★★	★★	Need further evaluation
Wind	★★	★★	★★★	★★★★	★★★	Need further evaluation
Biomass	★★★★	★★★	★★★	★★★★	★★	Ready for deployment
Biogas	★★	★★★	★★★★	★★★★	★★★	Ready for deployment
Geothermal	★★	★★	★★★	★★★★	n/a	Need further evaluation
Hydro	★	★★★	★★★	★★★★	★★	Ready for deployment

Notes: Star ratings are out of four stars, with one representing a low score and four representing an exceptionally good score; ★ = poor; ★★ = fair; ★★★ = good; ★★★★ = excellent; for the likely cost rating, the greater the number of stars, the lower the likely cost; technology maturity represents the global level of maturity; for a more detailed discussion of what each of these criteria means, please refer to (IEA, 2016).

[15] Quotas for each grid-connected renewable electricity source are listed in Section 3.4.

Step 2: Indicators, current penetration and costs

2.1 Indicators and current levels of market penetration

Renewable energy capacity totalled 1.2 GW in 2015 (Table 5), spread across a total of 645 installations, including both grid-connected and off-grid installations. Capacity information was made available by the Belarusian Ministry of Energy.

Table 5 • Current renewables capacity levels in Belarus

Renewable energy source	Capacity (MW)	Electricity capacity (MW)	Heat capacity (MW)
Biomass (wood, waste and agricultural)	6 130	130	6 000*
Wind	50	50	0
Biogas	24.8	24.8	n/a
Hydro	35.1	35.1	0
Solar PV	12.8	12.8	0
Solar heating	3.9	n/a	3.9
Geothermal (heat pumps)	10	0	10
Total	**6 266.6**	**252.7**	**6 013.9**

* Heat capacity includes plants that use both peat and biomass as fuel, interchangeably.
Source: Ministry of Energy.

Table 6 • Current off-grid renewables capacity in Belarus

Renewable energy source	Capacity (MW)	Electricity generation (MWh)
Biomass (wood, waste and agricultural)	7.4	1.6
Wind	49.9	10.1
Biogas	40.4	15.4
Hydro	13.1	4.6
Solar PV and heating	20.5	0.2
Total	**131.3**	**31.9**
Biodiesel	552 000 tonnes	

Source: Ministry of Energy.

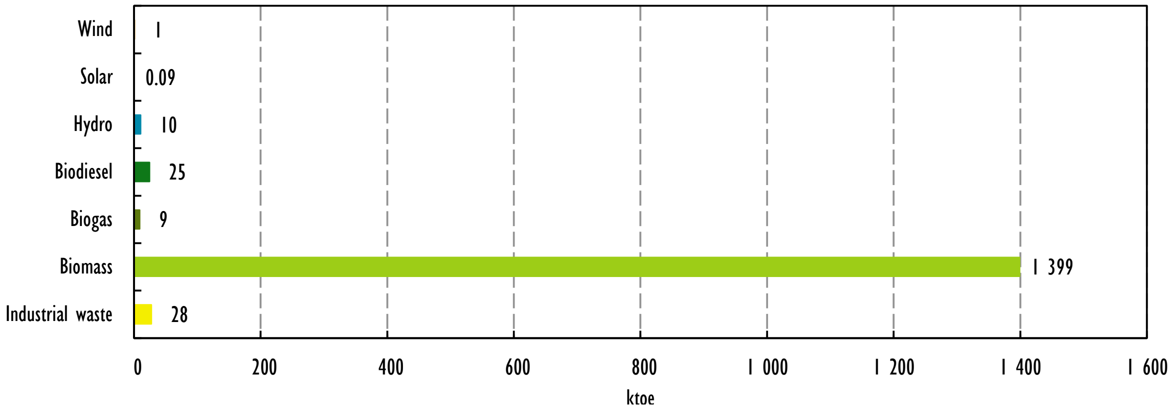
Data on the level of energy produced from renewables (including electricity and heat) are presented in Figures 10 to 12 and Table 7, and all data are sourced from the IEA.

As Table 5 shows, biomass has the largest existing grid-connected capacity for renewable energy generation, including wood and agricultural sources. Biomass capacity is mainly in heat power generation (6 000 MW) however that includes plants that can also use peat, depending on which fuel is available. Renewable heat capacity from other sources is negligible in comparison. Off-grid capacity for biomass is modest at 7.4 MW.

For grid-connected electricity, the largest source of capacity is from biomass (130 MW), followed by wind power with 50 MW of installed capacity. There is another 50 MW of off-grid wind capacity, making wind the primary source of renewable energy for off-grid applications in terms of installed capacity (Table 6). The third-largest source of renewable capacity is hydropower, with 35.1 MW of installed capacity, double the capacity in 2010 but still only a small percentage of its economic potential. Grid-connected biogas capacity totals 24.8 MW, while autonomous biogas plant installed capacity equals 40.4 MW, second only to wind. Grid-connected solar installations account for 16.7 MW of installed capacity, with 12.8 MW in solar PV electricity and 3.9 MW in solar heating. Off-grid solar PV and heating capacity totals 20.5 MW.

Belarus has around 10 MW of geothermal heating capacity (Meerovskaya et al., 2014). However, the installation of certain heat pumps (open-loop water-source heat pumps) in Belarus may be complicated as groundwater has high salinity, requiring more frequent and expensive cleaning. This would not affect closed groundwater or air-source heat pumps. Capacity for biofuels production is currently 552 thousand tonnes of oil equivalent (ktoe) per year.

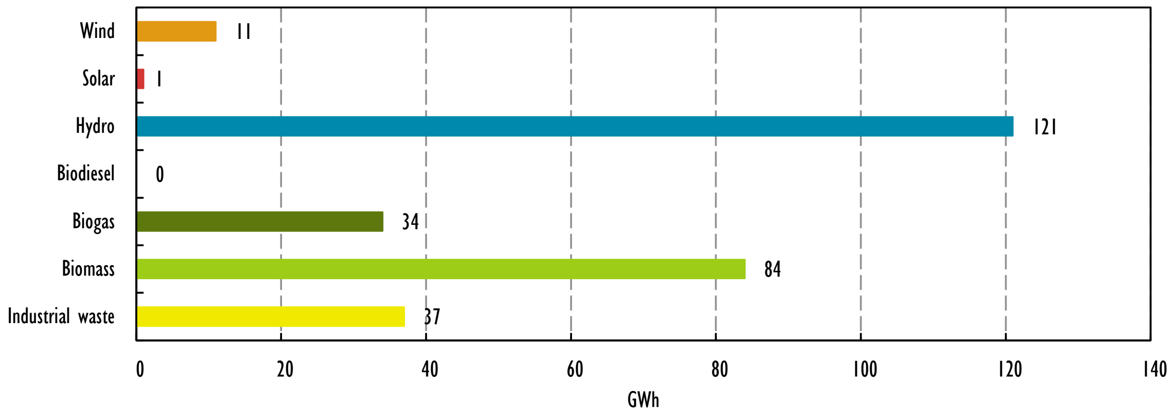
Figure 10 • Energy production from renewables in Belarus, 2014



Source: IEA (forthcoming), *Energy Balances of Non-OECD Countries 2016*, www.iea.org/statistics/.

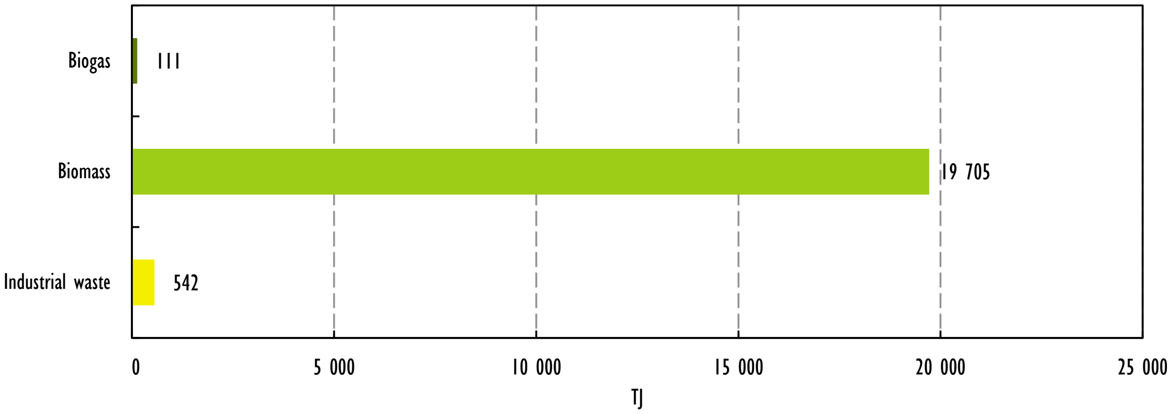
Figure 10 indicates total energy production from renewables by fuel in 2014. Figure 11 shows the breakdown of electricity generation from renewables per fuel/technology in 2014. Figure 12 shows heat generation from renewables per fuel, indicating that biomass is predominant.

Figure 11 • Electricity generation from renewables in Belarus, 2014



Source: IEA (forthcoming), *Energy Balances of Non-OECD Countries 2016*, www.iea.org/statistics/.

Figure 12 • Heat generation from renewables in Belarus, 2014



Note: TJ = terajoule.
Source: IEA (forthcoming), *Energy Balances of Non-OECD Countries 2016*, www.iea.org/statistics/.

Biofuels and waste

Bioenergy is the main source of renewables in Belarus. Table 7 indicates the levels of production and consumption of biomass, biogas and biodiesel in 2014.

Table 7 • Bioenergy production and consumption per sector, Belarus, 2014

	Biomass	Biogas	Biodiesel	% of total
Production (ktoe)	1 399.1	8.9	24.6	39%
Electricity from co-generation (GWh)	84	32	0	0.5%
Heat from co-generation (TJ)	2 465	111	0	1.7%
Heat from heat plants	17 240	0	0	16.6%
Consumption (ktoe)				
Industry	49.1	0.2	0	1%
Agriculture	40.6	0	22	5.5%
Commercial	219.4	0	0	9.4%
Residential	378.2	0	0	7.7%
Transport	0	0	2.6	<0.1%

Source: IEA (forthcoming), *Energy Balances of Non-OECD Countries 2016*, www.iea.org/statistics/.

2.2 Indicators and current levels of cost and remuneration

Grid-connected electricity

The IEA cost analysis (section 1.2 above) shows that, given Belarus's resource quality and availability, and the relatively high cost of financing, development of renewables from biomass and landfill gas are the least costly investments. The cost ranges of biogas (anaerobic digestion), wind, hydro, MSW co-generation and utility-scale solar PV are moderately higher, while commercial and residential solar PV and MSW plants are the most costly investments.

Table 8 indicates the latest FITs for different RETs, while Table 9 indicates the previous FITs that apply to projects secured before 20 May 2015. The FIT for grid-connected electricity produced from renewables is based on the regulated electricity tariff for industrial consumers with connected capacity of up to 750 kilovolt amps (kVA). A share of the tariff, 89%, is indexed to the USD exchange rate at 20 461 Belarusian roubles (BYR) per USD and uses a multiplier specific to different technologies (National Agency of Investment and Privatisation of Republic of Belarus, 2016). The exchange rate was last updated on 28 January 2016, increasing from 11 800 BYR/USD for the previous year. While the multiplier effect is fixed for a period of time, in practical terms the FIT is not, as the industrial tariff is reviewed annually. On 27 January 2016, the electricity tariff for industrial customers up to 750 kVA usage was 2 519.7 BYR/kWh (around 1.2 USD/kWh based on an assumed exchange rate of 20 461 BYR/USD) (Minenergo, 2016). In 2015, the industrial tariff was around 1.3 USD/kWh, or 1 580.2 BYR/kWh with an exchange rate of 11 800 BYR/USD.

Comparing the IEA estimated cost range and the FITs, the tariffs offered are relatively generous for all technologies in the lower cost range, particularly for biomass, landfill gas and utility-scale PV. Tariffs for wind, hydro and MSW co-generation are also generous in the lower cost range, while tariffs for smaller-scale PV fall short of the estimated cost. For the higher cost ranges, most offered FITs are insufficient to cover full cost and provide a return.

Table 8 • Value of FITs for plants commissioned after 20 May 2015, Belarus

Type of energy source	Feed-in tariff for the first 10 years* (multiplier and value in USD/kWh)	Feed-in tariff for the next 10 years of operation (multiplier and value in USD/kWh)
Wind energy for plants with the following age of equipment:		
- less than 5 years	1.2 (USD 0.154)	0.75 (USD 0.097)
- more than 5 years	1.05 (USD 0.135)	0.75 (USD 0.097)
Hydro power and geothermal energy:		
≤ 300 kW	1.2 (USD 0.154)	0.75 (USD 0.097)
301 kW – 2 MW	1.15 (USD 0.148)	0.75 (USD 0.097)
> 2 MW	1.1 (USD 0.142)	0.75 (USD 0.097)
Solar energy:		
≤ 300 kW	2.5 (USD 0.322)	0.75 (USD 0.097)
301 kW – 2 MW	2.3 (USD 0.296)	0.75 (USD 0.097)
> 2 MW	2.1 (USD 0.270)	0.75 (USD 0.097)
Energy from wood, biogas and other renewables:		
≤ 300 kW	1.3 (USD 0.167)	0.85 (USD 0.109)
301 kW – 2 MW	1.25 (USD 0.161)	0.85 (USD 0.109)
> 2 MW	1.2 (USD 0.154)	0.85 (USD 0.109)

* From the date of commissioning of electricity generation.

Note: USD exchange rate as at 4 December 2015.

Sources: Urodnich, R. (2015), "Renewable Energy in Belarus: new tariffs 2015", Insider Energy, 1 October, investinbelarus.by/en/invest/opportunities/directions/renewable-energy-and-new-materials/.

Table 9 • Value of FITs for plants commissioned or registered before 20 May 2015, Belarus

Type of energy source	Feed-in tariff for the first 10 years* (multiplier and value in USD/kWh)	Feed-in tariff for the next 10 years of operation (multiplier and value in USD/kWh)	After 20 years of operation (multiplier and value in USD/kWh)
Wind and geothermal	1.3 (USD 0.17)	0.85 (USD 0.11)	0.45 (USD 0.06)
Biogas and biomass	1.3 (USD 0.17)	0.85 (USD 0.11)	0.6 (USD 0.08)
Hydro	1.1 (USD 0.15)	0.85 (USD 0.11)	0.45 (USD 0.06)
Solar	2.7 (USD 0.36)	0.85 (USD 0.11)	0.45 (USD 0.06)

* From the date of commissioning of electricity generation.

Note: USD exchange rate as at 1 September 2015.

Source: Urodnich, R. (2015), "Renewable Energy in Belarus: new tariffs 2015", *Insider Energy*, 1 October, investinbelarus.by/en/invest/opportunities/directions/renewable-energy-and-new-materials/.

Step 3: Technology penetration and cost monitoring

3.1 Monitoring RET penetration over time

Electricity from renewable sources amounted to 288 GWh in 2014, or 0.8% of total electricity generation. This was 747% higher compared to 2004 (Table 10). Strong increases in electricity from hydro and biomass have been the largest contributors to this growth.

Table 10 • Electricity generation from renewables in Belarus, GWh, 2004-14

Renewable energy source	2004	2006	2008	2010	2012	2014
Industrial waste	0	0	0	9	32	37
Biomass	0	2	32	78	82	86
Biogas	0	0	1	6	13	34
Wind	1	1	1	1	6	11
Hydro	33	35	39	45	70	121
Solar	0	0	0	0	0	1
Total renewables	**34**	**38**	**73**	**139**	**203**	**288**
Share of total	0.1%	0.1%	0.2%	0.4%	0.7%	0.9%

Source: IEA (forthcoming), *Energy Balances of Non-OECD Countries 2016*, www.iea.org/statistics/.

Table 11 shows ten years of data on heat generation from renewables in Belarus. The share of heat generation from renewables has more than doubled over the ten years to 2014, from 3.4% to 8%, mainly due to an increase in the use of biomass. Biogas technology is also increasingly used in heat generation, albeit still at negligible levels.

Table 11 • Heat generation in Belarus, TJ, 2004-14

Renewable energy source	2004	2006	2008	2010	2012	2014
Industrial waste	683	592	791	618	584	542
Biomass	923	11 285	14 005	16 760	18 758	19 750
Biogas	0	0	3	23	46	111
Total renewables	**991**	**11 877**	**14 844**	**17 401**	**19 388**	**20 358**
Share of total	0.1%	0.1%	0.2%	0.4%	0.7%	0.9%

Source: IEA (forthcoming), *Energy Balances of Non-OECD Countries 2016*, www.iea.org/statistics/.

Table 12 indicates the level of production and consumption from biofuels in 2014 and five years earlier in 2009. It shows that biomass, biogas and biodiesel production is on the rise in Belarus, with a growing amount used in electricity and heat production and in all sectors other than households, where the use of biomass for heating and cooking has fallen. Demand for biodiesels in transport has also fallen over the five years.

During 2011-15, under the national programme for the development of renewables and energy efficiency measures, new installations constituted: 12 biogas complexes with 19 MW of electricity capacity; 7 hydropower stations with 19 MW; and 35 wind turbines with 25 MW of capacity.

Table 12 • Bioenergy production and consumption per sector, 2009 and 2014

Renewable energy source	Biomass	Biogas	Biodiesel	% total
	2014			
Production (Mtoe)	1 399.1	8.9	24.6	39%
Electricity from co-generation (GWh)	84	32	0	0.5%
Heat from co-generation (TJ)	2 465	111	0	1.7%
Heat from heat plants	17 240	0	0	16.6%
Consumption (Mtoe)				
Industry	49.1	0.2	0	1%
Agriculture	40.6	0	22	5.5%
Commercial	219.1	0	0	9.4%
Residential	378.2	0	0	7.7%
Transport	0	0	2.6	<0.1%
	2009			
Production (Mtoe)	1 319.6	1.4	20.2	35.2
Electricity from co-generation (GWh)	55	5	0	0.3%
Heat from co-generation (TJ)	1 524	28	0	1.1%
Heat from heat plants	13 854	0	0	11.3%
Consumption (Mtoe)				
Industry	36.8	0	0	0.8%
Agriculture	38.9	0	11.4	4.6%
Commercial	181.1	0	0	8.7%
Residential	491.3	0	0	10%

Source: IEA (forthcoming), *Energy Balances of Non-OECD Countries 2016*, www.iea.org/statistics/.

The surge in biofuels and waste production in Belarus has been mainly due to a strong policy towards developing this sector and financial support for producers. Given that most of the development has been in the heat sector, the grid connection issues related to electricity generation have not be a strong barrier to biofuels and waste development.

Looking ahead, future deployment of renewables technologies other than biofuels and waste can expect to be strongly linked not only to government support programmes and financial investments, but also to transparency in grid connection rules and contracts. This emphasises the importance on improving the overall enabling environment (discussed below).

Belarus's target of 9% of TPES to derive from renewables by 2035 is dependent on the level of future TPES, which is influenced by a number of factors including economic growth, the standard of living, structural reform, cyclical consumption, and others, and is therefore a more difficult measure of progress to monitor.

The government has not specified a target for renewable electricity or heat generation capacity. However, renewable electricity generation is projected to reach 2.6 TWh by 2035, or 6% of a total of 43.8 TWh (Figure 16). This is a significant increase compared to less than 50 GWh in 2013, and would require substantial investment in mostly grid-connected renewables. In the shorter term, according to the most recent programme on energy savings, the National Programme on Energy Efficiency and Energy Saving for 2016-20, the government is projecting the following additional capacity:

- thermal capacity of 680 MW from biomass and peat, through various new uses of biomass, including biomass gasification technologies involving waste wood feedstocks, creation of new wood pellet and briquette manufacturing processes, infrastructure improvements on the harvesting and transport of wood, improving transport and storage of biomass

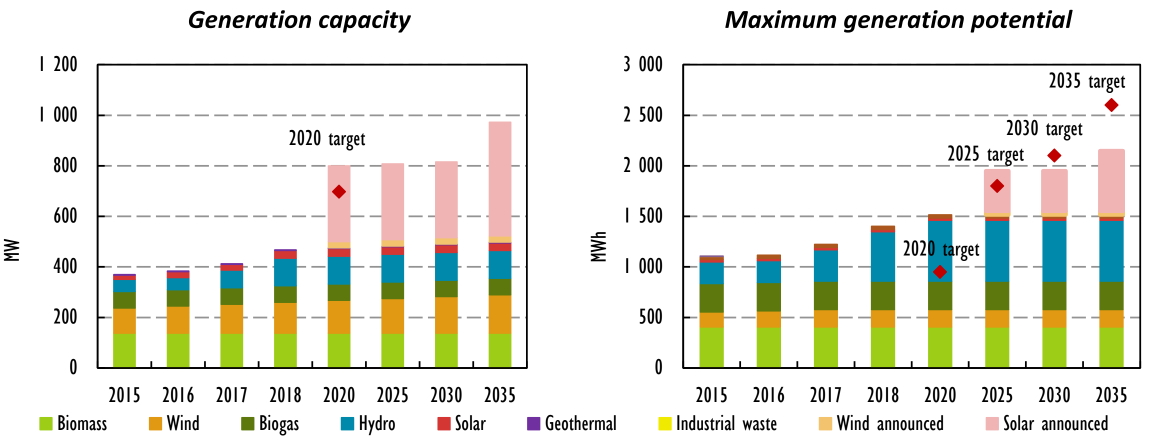
- electricity capacity of no less than 30 MW from biogas plants at wastewater treatment facilities, MSW landfills and cattle, pig and poultry farms
- 80 MW of hydropower, including the restoration of previously decommissioned small hydroelectric power plants
- up to 250 MW of solar PV and solar heaters
- no less than 200 MW of wind power capacity.

Figure 13 shows how progress in reaching this target can be monitored, from existing levels of electricity generation capacity to the expected levels in 2020 and 2035, based on currently available information on large-scale projects. Large-scale projects have been classified according to a four-tiered rating system:

1. Announced: Where the intention to develop a site and initial scoping studies have been conducted to estimate the potential capacity.
2. Planned: Where a process to select project developers has commenced. Requests for qualification or tender are carried out and a developer is selected. Project finance is secured.
3. Under construction: Construction of infrastructure at the site is under way.
4. Commissioned: Project is completed and is generating energy.

Using publicly accessible information on projects, it is then possible to chart the projected deployment of large-scale RETs for solar, wind and hydro, and to track how deployment levels compare against national targets. The information in Figure 13 includes quotas that have been specified to 2018; however, it does not assume any quotas after that date.

Figure 13 • Project electricity generation capacity and generation, Belarus, 2015-35



Note: Projects currently under construction are included in the total.
Source: IEA (forthcoming), *Energy Balances of Non-OECD Countries 2016*, www.iea.org.

According to the Ministry of Energy, projects under construction at the time of writing include hydropower plants Polotsk (21.7 MW by 2017) and Vitebsk (40 MW by 2018) and a wind farm of 7.5 MW capacity to be concluded in 2016. The largest solar plant, Smorgon, is currently under construction with a planned capacity of 17 MW by 2018. The first phase of the project (5 MW) was finished in 2015, the second, 6 MW, is planned by end-2016 and the third, 6 MW, by mid-2018. Two other large projects for solar development have been announced, one for 109 MW in the Mogilev Oblast (Seenews, 2016) and a 55 MW solar PV plant in the Rechitsa district (PV Magazine, 2016). Additionally, approximately 300 MW of solar power development were committed before the introduction of the quotas in 2015 (see Section 3.4 for further information), while wind development projects of around 25 MW are expected with the completion of the United Nations Development Programme (UNDP) project on removing barriers to wind power development in Belarus, expected to complete in 2019 (Naviny.by, 2016).

Figure 13 shows that existing capacity and the completion of projects under construction would be sufficient to cover the target of 950 GWh electricity generation from renewables, if the majority of the maximum generation potential was utilised. By 2025, however, at least some of the wind and solar projects that have been announced would have to be realised in order to reach the target, and by 2030 all announced wind and solar projects would have be to realised, and used to their full potential, alongside other currently unknown projects.

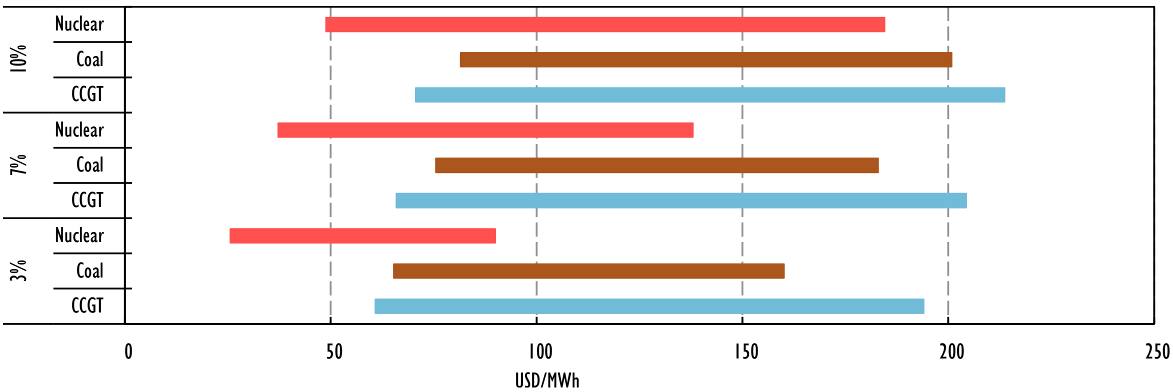
The government does not specify a target for renewable heat generation in Belarus, although it has expressed a priority for biomass and biogas heat generation. A number of projects are currently proposed and in advanced stages of planning, including a 20 MW biomass heat plant (The Baltic Course, 2016) and a larger World Bank-financed USD 90 million project on biomass district heating expansion and rehabilitation (World Bank, 2016b).

3.2 Monitoring and benchmarking the cost of RETs

According to the IEA (2015a), investment in renewables has been driven by generous market incentives, which have helped incentivise investment to reduce the cost of production, leading to falls in the average cost of renewables. Cost reductions have been most noticeable in solar PV and onshore wind, both in member countries of the Organisation for Economic Co-operation and Development (OECD) and OECD non-members. However, a wide variation in unit investment costs exists at the country level due to country-specific market dynamics and differences in balance-of-system costs (e.g. land, labour, permitting and licensing). Policy incentives also have an impact on the pricing of renewable energy equipment. In countries with high levels of incentive, investment costs can remain inflated as equipment is priced accordingly, taking into account developers' return expectations.

Actual historical costs of renewables in Belarus are not available for this study. However, were costs to be monitored over time and benchmarked against costs in countries with higher deployment levels, Belarus would be able to track the efficiency of its renewables development and competitiveness of its renewables market.

Figure 14 • Range of levelised cost of electricity for baseload technologies (at discount rates)



Notes: CCGT = combined-cycle gas turbine. The chart was prepared by the IEA and the Nuclear Energy Agency (NEA), according to the same methodology used to estimate costs in Figure 5.

Source: NEA (2015), *Projected Cost of Generating Electricity 2015*.

Belarus can also benchmark the cost of renewables compared to the cost of other traditional baseload technologies, and track it over time. This is particularly true for nuclear baseload, given the country's commitment to the development of a new nuclear reactor, expected to provide around 30% of total power generation. Figure 14 indicates the average cost range of gas, coal and NPPs, at different discount rates. At the highest discount rate of 10%, which is the closest to the estimated discount rate in Belarus, the range in the cost of nuclear is similar to wind, biomass and landfill gas, albeit lower than other RETs. If tracked over time, the differentials in costs can assist in policy development, price/tariff regulation and investor signalling.

3.3 In-country monitoring systems

Deployment of renewables in Belarus is monitored by the Energy Efficiency Department of the Standardisation Committee, which collects all the data on the deployment of certain programmes and provides the collected data to the National Statistics Committee for further manipulation and representation. Additionally, all enterprises must submit monthly electricity and heat generation questionnaires to the National Statistics Committee.

The government is also monitoring 11 energy security indicators for the purposes of energy policy development. The monitored indicators are technology neutral, and focus more on the general efficiency of the sector. Table 13 lists 7 of the 11 monitored indicators.

Table 13 • Seven of the main monitored indicators for energy security in Belarus

Indicator	2010	2015	2020	2025	2030	2035
Production as a share of TPES (%)	14	14	16	17	18	20
Renewables as a share of TPES (%)	5	5	6	7	8	9
Dominant import supplier (%)	96	90	85	80	75	70
Gas in TPES (%)	64	60	57	55	52	50
Installed electricity capacity to maximum actual load grid ration (%)	127	160	160	155	150	145
Share of gas in heat and electricity generation (%)	91	90	70	60	50	<50
Energy intensity of GDP, ktoe/BYR (2005 prices)	426	378	370	353	317	268

Source: Ministry of Energy, minenergo.gov.by.

Under the latest National Programme on Energy Efficiency and Energy Saving for 2016-20, the effectiveness of the programme will be measured in 2020 based on evaluation of achievement of the targets specified in Table 13, taking into account the extent of available and planned financing. The programme is deemed to be a success if a certain pre-set level of achievement is reached, under presumed funds, rather than the expectation of all tasks being fully completed.

The programme includes two sub-programmes, one for renewables (and other local fuel development) and one for energy efficiency. Each sub-programme is monitored closely by the Ministry of Energy and rated against a number of criteria, including rate of implementation and impact, using the metrics in Table 13.

As shown in Table 13, Belarus's energy security indicators only capture aggregate RET deployment in terms of renewables as a share of TPES. No formal monitoring system has been established to report on the progress of deploying specific RETs nor to show the link between the level of capacity of renewables and the share of renewables in TPES or TFC.

3.4 Enabling environment for priority technologies

The enabling environment for RET development in Belarus is considered to be consistent but lacking in incentives for investors, as strategic targets are low. However, the overall investment climate in Belarus is improving, with legislation that favours foreign investors, including the most recent changes to the rules and regulations that increased transparency and clarity on electricity production, large consumption and connections to the grid.

Institutional and regulatory factors

Institutional framework

The **Ministry of Energy** is responsible for the fuel and energy sector of Belarus. It manages the vertically integrated state-owned natural gas supplier, BelTopGaz, and the vertically integrated state-owned electricity producer, supplier and retailer, BelEnergo. This ministry also oversees the State Enterprise "Belarusian Nuclear Power Plant" and other state-owned organisations operating in the energy sector. It is responsible for the implementation of the State Programme on the Development of the Electricity System of Belarus for the Period to 2016.

The **Energy Efficiency Department** of the State Standardisation Committee is responsible for the development and implementation of national energy efficiency and renewable energy policies. It also monitors and ensures state control over rational use of fuel, electricity and heat.

The **Ministry of Economy** is responsible for setting tariffs and evaluating investment projects/financing.

The **Ministry of Natural Resources and Environmental Protection** has the responsibility of managing the environmental concerns of the energy sector, and is the holder of the largest inventory of renewable energy information in Belarus. The inventory tracks and monitors the level of renewable energy development.

State regulation of the energy sector, including energy efficiency and renewable energy, is carried out through decrees, directives of the president, government decisions and the Ministry of Economy. Other relevant ministries and departments are active participants. The Energy Efficiency Department of the State Standardisation Committee is responsible for monitoring energy efficiency and renewable energy deployment in Belarus.

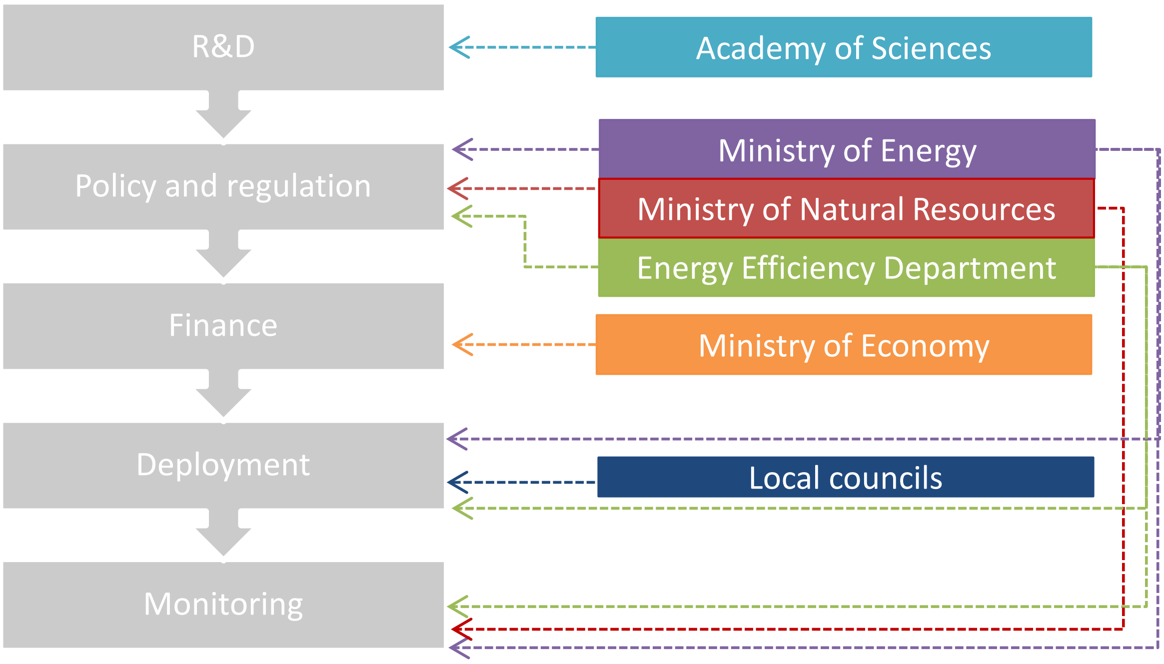
The **Academy of Sciences** organises and co-ordinates fundamental and applied research on the natural sciences, engineering, social sciences, the humanities and arts, in line with the country's goals and policies. It also monitors the indicators of energy security and develops concepts for maintaining the indicators and is responsible for scientific and technical research in the implementation of projects related to renewable and alternative energy.

Local councils, executive authorities and administrative bodies implement regional/local energy programmes. A number of public and non-governmental organisations are active in the field of energy efficiency, renewable energy and environmental protection in Belarus.

Figure 15 illustrates the key players in renewable energy development in Belarus.

The **National Statistical Committee** is responsible for administering the laws on national data services. It collects, processes and publishes national statistics, including energy data. The Statistical Committee is responsible for preparation of energy balances, which it does in close co-operation with the Ministry of Energy and energy enterprises.

Figure 15 • Institutional framework for renewables development, Belarus, 1990-2013



Policies and regulations

The Belarusian government has selected renewable energy as a priority for the energy sector, as it provides for energy security through a reduction in imports and reduces GHG emissions. In 2011, the National Programme on Local and Renewable Energy Development for 2011-15 was launched, with detailed plans and projections for the development of all local resources, with a particular focus on biomass and biogas development.

The new Concept of Energy Security has no binding target for renewables as a share of the energy mix; however, the government aims to reach a 9% share by 2035 (up from just under 6% in 2013). While not a key policy target, electricity generation from renewables is expected to grow 10-fold to 2.6 TWh by 2035.

In 2015 the Belarusian government amended the regulation on renewable energy that was governed by the Law on Renewable Energy Sources adopted in 2010. In May 2015, the government approved the Presidential Decree on the Use of Renewable Energy and in August 2015 it approved the resolution on a new methodology for FITs. In March 2016 the government approved the Comprehensive Development Plan for the Electricity Sector to 2025, and in April 2016 the National Programme on Energy Efficiency and Energy Saving for 2016-20 was approved.

The new legislation on renewables in May and August 2015 effectively changes the previous FITs and it legislates quotas on grid-interconnected renewable energy development (new plants and modernisation/rehabilitation that lead to an increase in capacity). Off-grid developments and developments under contract before 20 May 2015 are not subject to the said quotas. According to the government, the new tariffs are more likely to attract investors while the quotas maintain the sustainability of renewables development and grid balancing. At end-2015, the Ministry of Energy was working on developing a new National Programme for the development of renewables for 2015-20.

The quotas are applicable to the period 2016-18 and total 215 MW of renewable energy. Table 14 indicates the year-to-year quotas by energy source.

Table 14 • Quotas per renewable energy source per year

MW	2016	2017	2018	Total
Biogas	10	10	12	32
Wind	10	10	30	50
Solar	5	5	5	15
Hydro	5	5	72	82
Biomass	13	13	10	36
Total	**43**	**43**	**129**	**215**

Source: BelSEFF (2015), "The Programme of Financing Energy Projects in Belarus", presentation, 13 October, Minsk.

While renewables could play an important role in meeting Belarus's strategic needs to reduce fuel imports and to reduce energy-related GHGs, the current Belarusian policy framework does not provide a strong supportive framework for future renewables development – it lacks clear targets for renewables development and has no binding goals. The main aim of the policy is to provide energy security for Belarus by diversifying its energy mix through an increase in the use of local fuels, in a number of ways other than investing in renewables, leaving the future of this investment in uncertainty.

Indeed the quota system, which is intended to constrain deployment of some variable renewable generation technologies, will dissuade investors seeking signs of a substantial market in the coming years to justify their investment. Equally, the monopolistic structure of the energy sector at present limits investor confidence and can result in preferential treatment for local monopolies.

Within the Comprehensive Development Plan for the Electricity Sector to 2025 (approved on 1 March 2016), the main planned changes to the regulatory framework include amendments to the Law on Electricity and the Law on Heat Supply, to account for the development of the new NPP, to include incentives for attracting investment in electricity and heat from local energy sources, and to plan for the rehabilitation of both systems. These amendments are expected to lead to a more stable and transparent regulatory framework, which in turn should stimulate the necessary investment.

With regard to the supply chain, Belarus imports most of the equipment necessary for renewables development, while producing some parts for energy-efficient boilers. The government is planning to expand local manufacturing into production of electric boilers in the near future. Installation and maintenance are carried out locally.

Technical and infrastructure factors

The key limitation to renewables development, as considered by the government under its strategy, is grid connectivity and balancing. Third-party electricity grid connection in Belarus has been allowed since 2013, after decades of restricted access to the vertically integrated monopoly BelEnergo. BelEnergo has indicated potential problems with lack of regulation of grid connections by renewable technologies, including problems with overloading, balancing and cost recovery of the connection. However, experience elsewhere indicates that relatively high levels of renewables can be successfully integrated without technical problems or high costs by adopting certain technical and management measures.

In order to reduce the risk of overloading the grid, the government has introduced quotas on the development of renewables (see Energy policy framework section above). In October 2014, the government also approved the President's Decree on the grid connection of electricity generators, with rules on:

- The connection contract between the generator and the network.
- Administrative procedures.
- Fees, technical conditions and fee-free network expansions.
- The Ministry of Economy being able to set maximum or fixed fees for grid connections.

The decree does not specify dispatch rules.

According to the Belarusian Web Portal on Renewable Energy (2015), a potential renewable energy generator applies to the regional energy company (the network) with an investment proposal, specifying the intended capacity, the type of plant and the location. The proposal is considered by the Scientific and Technical Board of the company (in conjunction with the network department of BelEnergo), stating any limits or preferences (e.g. the location), in accordance with their internal network development plans. Finally, the potential generator produces documentation for the connection (a system study that determines the optimal way of connecting to the network and the necessary network reinforcements) and the overall generation project feasibility study.

The system study consists of an estimate of the total connection costs, including expected changes in power flows and necessary network reinforcement costs (it is not clear how these costs are to be determined). The study must be undertaken by certified design institutes, which tend to be certified for connection studies at certain voltage levels. The preference expressed by the network's development plan is expected to be followed. The source data used for the system study must be agreed between the parties and therefore the network has to co-operate with the design institute chosen by the developer for the system. The feasibility study must also be done by a licensed design institute.

The following specifications for the grid connection process are also provided by the Belarusian Web Portal on Renewable Energy:

- The project documentation undergoes assessment by the environmental authorities, the local authorities and the construction supervision authorities, and at each stage obtains the appropriate signatures and stamps.
- Technical specifications are issued by the network (for a fee) upon completion of the previous steps (in particular once the feasibility study has been approved and the documentation proving access to land needed for the project has been obtained). Technical specifications list the detailed technical requirements for the particular connection, including requirements for reconstruction in the network, settlement metering, relay protection and automation, among many others.

The generator may negotiate the technical specifications with the network. Once the network fee has been paid a connection contract is set up.

Under the Law on Renewable Energy, renewable energy generators have to bear the cost of connection up to the closest possible connection point on the network, while the cost of upgrading and required modernisation are met by the network operator. The recovery of costs incurred by the network operator in connecting renewables facilities is not assured in the current tariff regulation methodology (Belarusian Web Portal on Renewable Energy, 2015).

Besides the capacity quotas imposed by the government in 2015, certain capacity limits could be imposed by the network development plans of the Scientific and Technical Board of the network operator (in conjunction with the network department of BelEnergo).

A new technical regulation on energy supply became effective from 1 February 2016. The regulation covers, among other technical aspects, grid connection of independent power producers, including renewables. The new legislation clarifies technical terms for the connection of independent power stations, excluding renewables from many technical regulatory aspects (such as taking part in the energy dispatching, providing schedules of output etc.).

Financial and market factors

A set of tariffs is available to investors in renewable generation systems. However these appear to be uncertain as they are based on a multiplier applied to the industrial electricity tariff, which can change from year to year. This means that investors will be exposed to significant uncertainties in the income they can expect to achieve. This is likely to discourage investment, or at best mean that investors demand a high return on their investment to counter the high risk profile. Markets that have been successful in achieving sustained growth in deployment and low costs are characterised by a payment regime that provides a fair but predictable income stream that provides confidence to investors.

Capital investment requirements and availability of finance are key limitations in Belarus, as for example with municipal waste processing plants that require large capital investment, have high operating costs and require specific technologies, which can be expensive, for processing largely unsorted municipal waste (Meerovskaya, 2014). Additionally, further limitations on development are posed by the lack of experience of local municipalities or similar administrations with new projects in energy and their lack of interest in commercialising the businesses. Financing accessibility is limited, a concern that is echoed around the world, and its cost is moderately high – estimated at around 11-12%.

Around 11% of foreign financing is exposed to exchange rate fluctuations. The remaining 89% is generally pegged to the US dollar. During 2015, the value of the Belarusian rouble halved against the US dollar, which is having a significant effect on the cost of borrowing in foreign currencies. Its value against the Russian rouble reached a low in January 2015 but has returned to its normal levels since March 2015. Therefore, the cost of finance from Russia, the main lender to Belarus, has remained relatively unchanged due to currency changes, albeit availability has fallen due to Russia's financial woes.

Practically, this can lead to a delay in renewables deployment due to expensive and scarce financing opportunities for local and Russian investors.

In general terms, however, Belarus's investment climate and ease of doing business are improving, with the country ranking 44th in World Bank's ease of doing business ranking, out of 189 countries in 2016. This represents an improvement over time, increasing from 57th in two years alone.

For the implementation of the National Programme on Energy Efficiency and Energy Saving for 2016-20, finance for the sub-programme on the development of local energy sources (including renewables) is planned from the budget, government loans, the Development Bank of Belarus, and private domestic and foreign investment.

Foreign investors sign agreements with the government, with the following incentives:

- exemption from import duties and value-added tax (VAT) on imported equipment
- exemption from land tax or rent payment for the land provided for the construction of the project
- ability to secure a land plot of the required size without holding an auction
- entitlement to the deduction of the full amount of VAT paid during the project on acquisition of the goods and equipment, property rights and construction
- entitlement to appoint contractors under the project without holding a tender.

In small and medium-sized towns and rural areas the foreign investor is exempt from the following:

- import duties and VAT on imported equipment
- profit tax for the first seven years from the registration date
- real estate tax, state duties for obtaining special permissions (licences), contributions to innovation funds (National Agency of Investment and Privatisation of Republic of Belarus, 2016).

Tariff subsidies

Energy tariffs, including electricity, heat, natural gas and liquefied petroleum gas (LPG), but excluding oil products, are subsidised in Belarus. As such, consumers are unaware of the true cost of energy and are not incentivised to save. Subsidies mainly apply to households, with cross-subsidies from relatively high industry tariffs. Subsidies also allow for less efficient technologies in electricity and heat generation, creating barriers to the development of new energy sources such as renewables.

In the new Comprehensive Development Plan for the Electricity Sector to 2025 (approved on 1 March 2016), the government set out plans to fully phase out cross-subsidies in the electricity sector, including setting transparent and cost-reflective tariffs for production, transmission, distribution and retail sectors. New tariff reforms would also include a larger category of consumers and different tariffs per time period. Once implemented, the phase-out of subsidies would allow the government to reduce artificially high industry tariffs, which would promote industry growth and provide other financial incentives to future investment.

Social factors

Public awareness of renewables in Belarus is growing and is related to the desire to reduce gas imports and increase energy efficiency. However, there remain segments of general public that hold the view that RETs are costly and difficult to integrate into the existing network, and that their development would lead to higher prices and problems in the grid. This is most likely due to a lack of information about the benefits of RETs, especially in light of recent technological developments and other countries' experiences in successfully integrating them into the grid.

The Energy Efficiency Department is responsible for an on-going public awareness campaign on renewables and energy savings. More needs to be done particularly in light of very low household tariffs and access to cheap gas. In addition, the government has been promoting the new NPP as the most important change to Belarus's electricity supply in the medium to long term, which may be detracting attention from other electricity supply technologies.

With regard to education and investment in human resources, the education system is adapting to the growing importance of energy management, with three universities offering EET programmes. There is also a training centre on renewable energy.

Environmental factors

Belarus has a goal of reducing GHG emissions, with the most recent pledge at COP21 to reduce emissions by at least 28% in 2030 compared to 1990. In 2013, energy-related CO_2 emissions accounted for around 80% of the total, and were 41.6% lower than in 1990, mainly due to a collapse in the energy sector after independence. Energy-related CO_2 emissions have been increasing slowly since the early 2000s, and are expected to continue to grow with rising energy demand, while still meeting the target.

There are no major environmental concerns over renewables development in Belarus. The country's environmental protection framework is reasonably developed and regulation is strong in the field of natural resources management. This is particularly true for the country's vast forest land, with well-established regulation and monitoring of development and use of forest land. The Ministry of Forestry, which is in charge of environmental monitoring of forest lands, allows for vast use of forest residues for biomass within its regulation. The Ministry of Natural Resources and Environment is responsible for surface water monitoring and agriculture, setting the standards and evaluation of hydro and biogas development in Belarus. The State Committee on Property is responsible for land monitoring and allowing land to be used for wind or other power stations.

Lessons learned from the pilot study

Data quality review

The main sources of information for the analysis of renewables were IEA annual balances data for Belarus (which are provided directly by the country) and secondary research using readily available publications and Belarusian government websites (including the renewable energy cadastre). The Ministry of Energy, through its Scientific Research and Project Republican Unitary Enterprise (BelTEI), has provided key supplementary information on energy policy and latest country developments, while information from their website and other ministries' websites has been used to obtain specific dates/figures.

During the course of the pilot study, it was noted that Belarus's data collection and quality control is of a high standard, resulting in a complete set of key data for renewable energy potential and current levels of market penetration. Where data is lacking at the moment is in the actual costs analysis of RETs, requiring estimated cost ranges to be used. Actual cost monitoring and information on the weighted average cost of capital, and comparisons against international benchmarks, would improve the ability of the government to make informed decisions about renewables deployment and provide a clearer picture of market conditions for renewables in Belarus.

Recommendations on future users of the methodology in Belarus

Given that the Energy Efficiency Department has the responsibility for implementing RETs in Belarus, it is the logical agency to use the methodology in the future.

Results of the pilot study for EETs

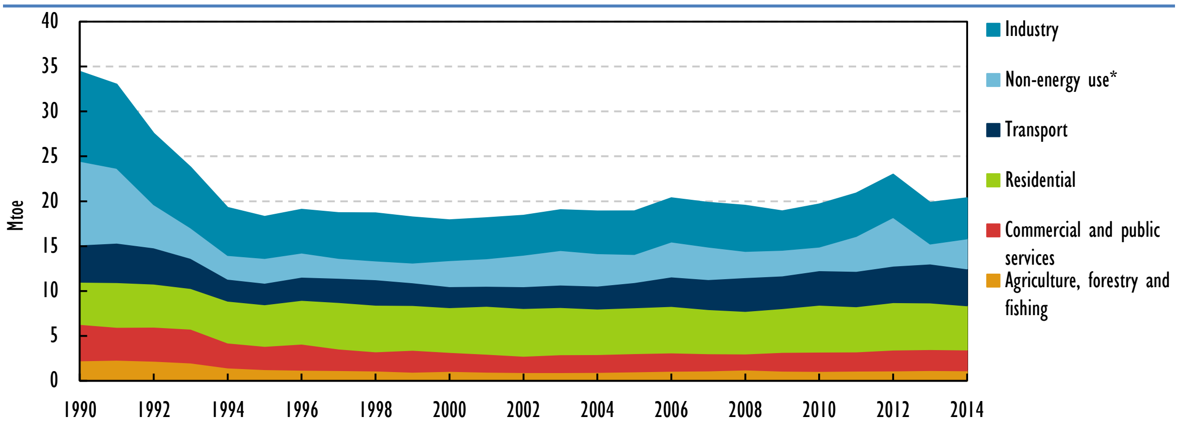
Step 1: Prioritisation

1.1 National energy end-use data analysis

According to IEA statistics on TFC for Belarus, the residential sector consumes the most energy with a share of 24%, followed by industry (22%) and transport (20%). Commercial and public services sector accounts for 11%, with agriculture, forestry and fishing consuming 6% of TFC (Figure 16). Non-energy use accounts for 17% of TFC.

Final energy consumption has remained relatively constant since 1994, while there has been some volatility in demand since the global financial crisis of 2008. Figure 9 in the section on market opportunities for renewables gives some explanation of the main changes in consumption patterns for the period 2004-14.

Figure 16 • TFC by sector, Belarus, 2014



* Non-energy use represents fuels used as raw materials.

Source: IEA (forthcoming), *Energy Balances of Non-OECD Countries*, www.iea.org/statistics/.

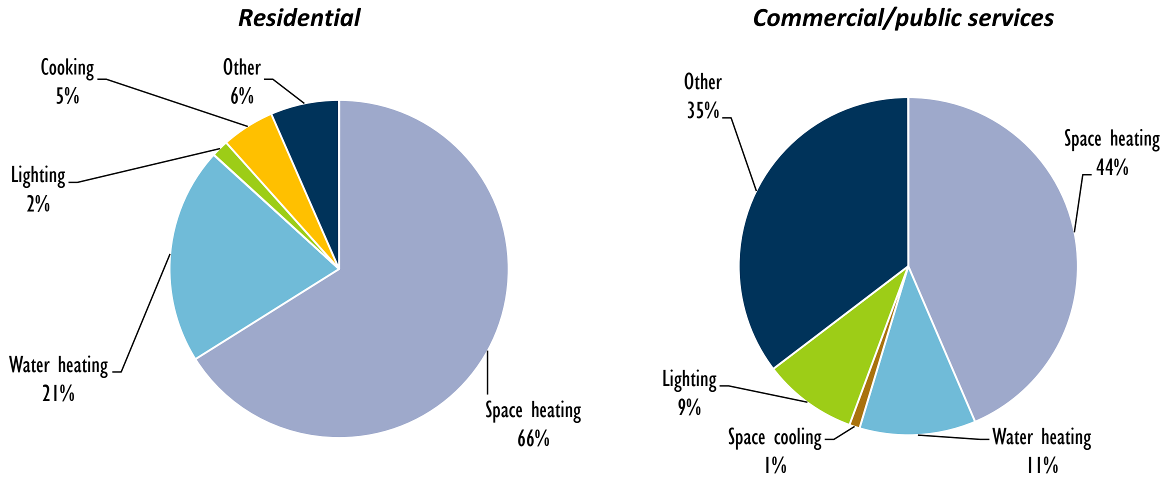
The following analysis will concentrate on a more granulated breakdown of energy consumption in the three largest consuming sectors, combining the commercial and public services sector with the residential sector.

1.1.1 Residential sector and commercial and public services energy use

At the time of writing, Belarus was completing its first household energy survey, which will, when finalised, show results for the amount and type of fuel and energy sources used in households per unit of measure, including square metres, number of occupants, etc. As the survey was not finalised at the time of writing, a Russian study is used as a proxy in Figure 17, given its geographical position and similarity in residential and commercial building stock. Russia and Belarus share a similar climate, namely sub-zero temperatures in the winter, with similar district heating needs and infrastructure.

Figure 17 shows that space heating and water heating consume the largest share of energy in the residential sector, while space heating and cooking are the largest end-users in the commercial and public services sector.

Figure 17 • Residential and service sector energy consumption breakdown, Russia, 2010

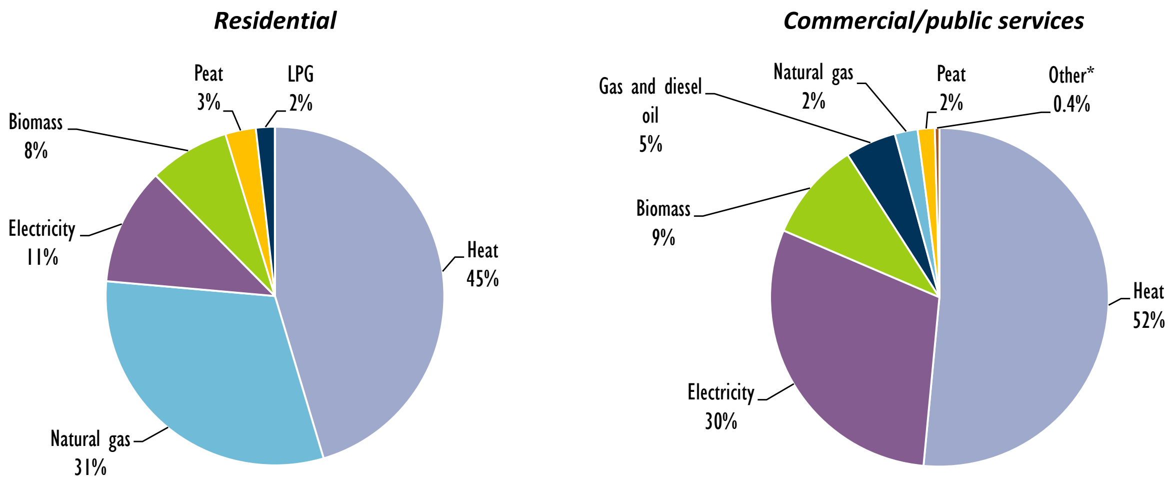


* Other includes appliances and other equipment.

Source: IEA (2013), *Transition To Sustainable Buildings; Strategies and Opportunities to 2015*.

Figure 18 shows the type of fuels that are consumed in the residential and the commercial and public services sectors in Belarus. Information on the different fuels per end-uses in households is not available at present, but will be available once the household survey is finalised. Information on the services end-use by fuel will not be available for Belarus until a survey is conducted.

Figure 18 • TFC by source in residential and services sectors, Belarus, 2014



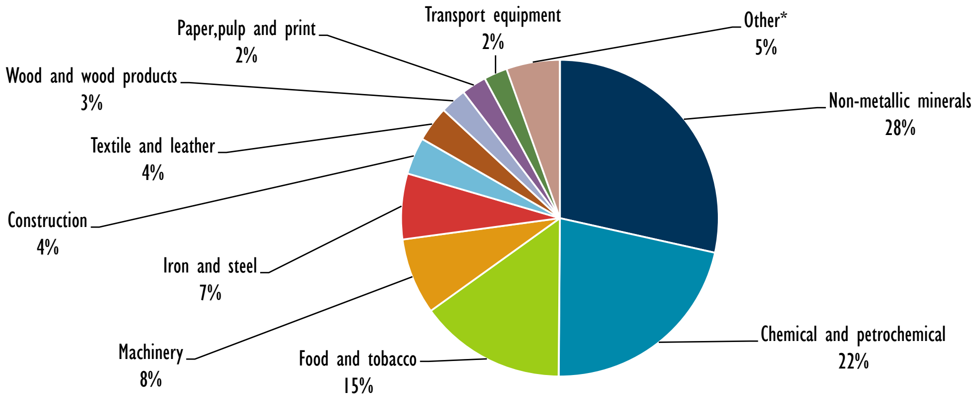
* Other includes other oil products and renewables.

Source: IEA (forthcoming), *Energy Balances of Non-OECD Countries 2016*, www.iea.org/statistics/.

1.1.2 Industry sector energy use

Figure 19 shows a breakdown of energy consumption in the largest industries in Belarus. Non-metallic minerals (cement and similar products) is the largest consuming industry with 28% of total industry demand, followed by chemical and petrochemicals (22%) and food and tobacco (15%).

Figure 19 • Industry TFC by type of industry, Belarus, 2014

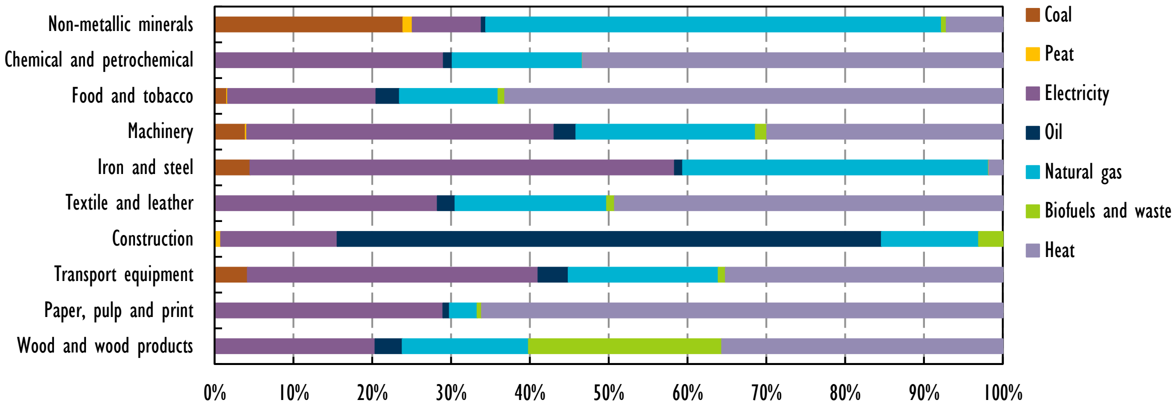


* Other includes mining and quarrying, non-ferrous metals and non-specified.

Source: IEA (forthcoming), *Energy Balances of Non-OECD Countries 2016*, www.iea.org/statistics/.

Figure 20 shows total final energy consumption by the largest industries separated by fuel. It indicates that heat and electricity play a significant role in manufacturing processes, while industries such as non-metallic minerals, iron and steel, and construction also consume large quantities of primary fuels – coal, gas and oil. The wood and wood products industry uses wood residues for around a third of its energy needs.

Figure 20 • Industry TFC by fuel, Belarus, 2014



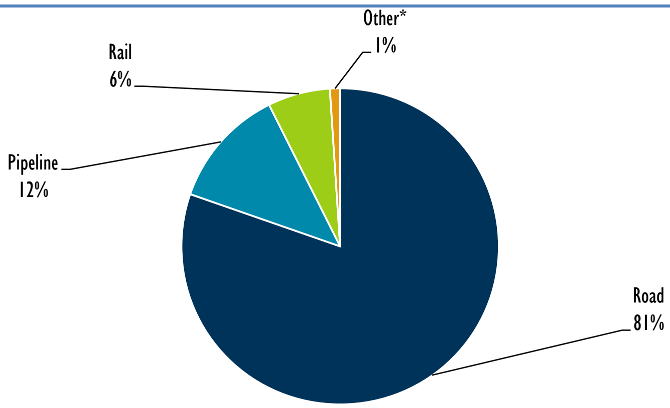
Source: IEA (forthcoming), *Energy Balances of Non-OECD Countries 2016*, www.iea.org/statistics/.

1.1.3 Transport sector energy use

The breakdown of transport energy consumption by mode is available in Figure 21. Road transport represents 81% of energy consumed, rail around 6%, while pipeline transport accounts for 12%. Domestic air travel consumes around 0.5% of the total.

Figure 22 shows the breakdown of different modes of transport and which fuels they rely on. Road transport is almost solely dependent on oil, while electricity is used in pipeline and rail transport. Coal and peat also play a small role in rail transport.

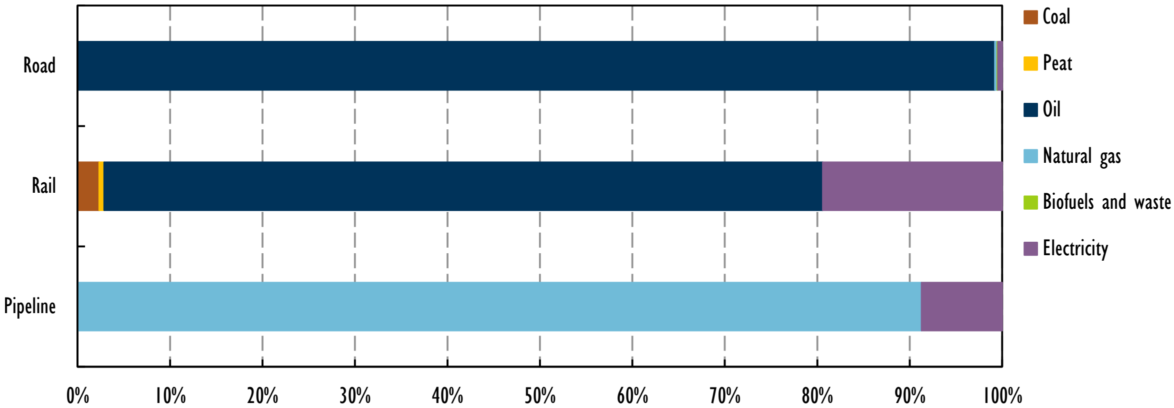
Figure 21 • Transport TFC by mode, Belarus, 2014



* Other includes domestic air transport and non-specified.

Source: IEA (forthcoming), *Energy Balances of Non-OECD Countries 2016*, www.iea.org/statistics/.

Figure 22 • Transport TFC by fuel, Belarus, 2014



Source: IEA (forthcoming), *Energy Balances of Non-OECD Countries 2016*, www.iea.org/statistics/.

1.2 Future energy use drivers and policies

This section summarises some of the key trends, drivers and policies that may affect future energy consumption in each of the major end-use sectors. It is not an exhaustive examination of all of the factors that will determine future energy use. Detailed modelling would be required for a deeper understanding of future trends in energy consumption and to examine how a range of drivers work simultaneously to influence energy demand.

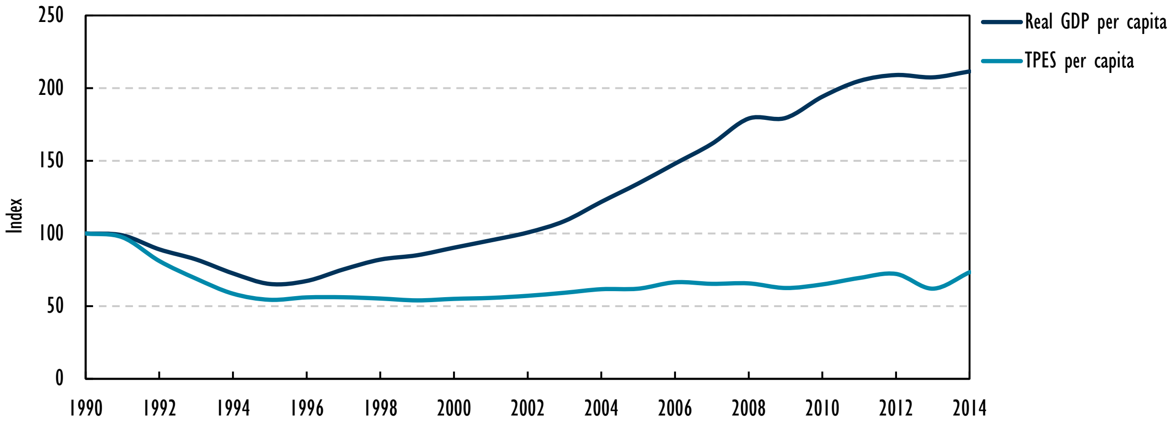
1.2.1 Overall drivers

Economic growth

Belarus's real GDP (measured as 2010 USD prices at PPP) was 71% higher in 2014 compared to 2004, and its real GDP per capita was 76% higher over the same period (the Belarusian population was 3% lower in 2014 compared to 2004). Historically, economic growth has been viewed as a leading driver of energy use, as greater prosperity has tended to increase demand for energy services (mobility, heating and cooling, communications, etc.), leading to net increases in energy use.

Figure 23 shows the trend in real GDP per capita and TPES per capita in Belarus from 1990 to 2014, indexed to the 1990 base year. The figure indicates that in Belarus, decoupling of real GDP and TPES began in the mid-1990s, after its independence from the Soviet Union. Similarly, energy intensity measured as TPES per unit of GDP has decreased significantly.

Figure 23 • Real GDP per capita and TPES per capita, 1990-2014



Source: IEA (2015b), *CO_2 Emissions from Fuel Combustion 2015*, www.iea.org/statistics/.

The decoupling may have occurred for a number of reasons, none of which can be directly credited without a detailed study of the effects. Data show that Belarus's economy is undergoing a structural change, with the fall in industrial demand offset by an increase in transport and services, while residential sector demand is remaining relatively constant (partially due to a fall in population). However, it is likely that, to an extent, the decoupling has been the result of technology choices. Developing countries such as Belarus have the opportunity to "leapfrog" energy-intensive phases of development due to the availability of improved technologies at the time of development, allowing them to decouple energy use and economic growth much more quickly than many developed countries achieved.

That said, the process of deploying highly efficient technologies will take time and, in the short term, it is still necessary to consider how economic growth *could* affect energy demand. This particularly applies for the purposes of identifying sectors that may require interventions to spur the deployment of EETs. For example, in the transport sector, vehicle ownership generally increases with rises in GDP per capita. As per-capita GDP grows from what is still a very low base in Belarus, it is likely that demand for mobility – in the form of passenger vehicles and other forms of transport – will grow with it, leading to a net increase in energy use. Similarly in the residential sector, IEA modelling of other developing economies suggests that increasing income tends to drive demand for larger, more comfortable buildings and more diverse energy end uses (IEA, 2013a). Unless super-efficient technologies are used, demand for increased energy services in households tends to lead to net increases in energy use. This tends to be partially offset by availability of energy-efficient equipment, which sometimes has high up-front costs and is attractive to certain levels of income and above.

Urbanisation and population density

Urbanisation and population density are key drivers of change in energy consumption patterns. Urbanisation tends to lead to a decrease in residential sector energy consumption per unit of surface area, as household sizes tend to fall when moving from rural to urban areas. Demand for services also increases, while agricultural and industrial output are likely to be negatively affected. Urbanisation and population density, particularly in urban areas, may also affect transport energy use. As population density increases, particularly in urban areas, the necessity and economic viability of public transport systems increases, leading to a shift toward more energy-efficient forms of transport than fossil-fuel powered passenger vehicles.

According to the World Bank World Development Indicators database (World Bank, 2016a), the share of population living in urban areas in Belarus was 75% in 2014, increasing slowly from around 67% in 1990. However, population density has fallen somewhat from 49.3 people per km^2 in 2000 to 46.7 people per km^2. The overall trend in the country has been one of the population moving from rural to urban areas where density is higher, albeit over the past decades their living space has expanded. The Belarusian government's overall policy includes plans to reduce the move from rural areas to Minsk, or rather incentivise the population to live and work in the same areas of origin.

National energy efficiency policies and target

The Concept of Energy Security is the key policy document for energy efficiency measures in Belarus at the moment. In April 2016, a new Energy Efficiency and Energy Saving Programme for 2016-20 came into force, which follows the previous five-year national programme. According to the new Concept on Energy Security, energy efficiency in both supply and demand is key to curbing demand growth and reducing gas import dependency. Planned measures to increase energy savings and improve efficiency are outlined in the policy document and can be summarised as follows:

- economic reform that leads to development of less energy-intensive industries
- use of modern energy-efficient technologies in all sectors, including electric and hybrid vehicles
- increase in energy efficiency requirements in standardisation
- improvement in energy consumption monitoring systems
- economic and organisational mechanisms to stimulate energy savings
- shift to energy-efficient construction and refurbishment of existing buildings
- improvement in surveying of energy activities and projects.

The main energy efficiency indicator for monitoring progress is GDP energy intensity. The Concept's targets for the country are listed in Table 15. Effectively, the government is planning to halve GDP energy intensity by 2035 compared to 2010 levels.

Table 15 • GDP energy intensity in Belarus including projections, 2010-35

Indicator	2010	2015	2020	2025	2030	2035
Energy intensity of GDP (in 2005 prices), ktoe/BYR million	426	378	370	353	317	268

Source: Ministry of Energy, minenergo.gov.by.

The main target of the National Programme on Energy Efficiency and Energy Saving for 2016-20 is to save around 3.5 Mtoe over the five years, through energy efficiency measures. The energy intensity of GDP target is a reduction of a minimum of 2% in 2020 compared to 2015. Energy savings are planned to be achieved despite an increase in overall energy consumption, by monitoring energy use in power generation, transformations and the industrial sector, and through planned reductions based on the previous five-year energy consumption patterns, including projections of output and economic activity.

Under the previous five-year programme, for 2011-15, energy savings of 55Mtoe were achieved, through the introduction of modern energy-efficient technologies, new processes, new and efficient equipment and materials, and the construction of new energy infrastructure.

Financial incentives

The National Programme on Energy Efficiency and Energy Saving is estimated to cost around USD 5 billion, of which about a fifth is expected to be financed from the state budget. The remainder is envisaged through private financing, soft loans from international financial institutions, loans from the Development Bank of the Republic of Belarus, and other financial market instruments.

There is no specific government fund dedicated to providing financial incentives to energy efficiency programmes, although the Energy Efficiency Department monitors the level of investment in EETs.

The EBRD has a credit line of USD 50 million in Belarus, for projects in the private and public sector investing in energy efficiency and renewable energy. This credit line is the Belarus Sustainable Energy Finance Facility (BelSEFF, 2015). Projects in energy efficiency are selected based on their financial viability and applicability within the technology criteria, and are given soft loans from the EBRD through a set of local participating banks. However, the majority of the loans administered within the fund to date have been in renewables projects.

Energy service companies (ESCOs) do not exist in Belarus at present and awareness of the concept and the benefits is low. ESCOs provide energy audits and consultation but also finance or arrange financing for energy efficiency operations and measures, with remuneration directly tied to the energy savings achieved. Development of an ESCO market can build capacity, address public procurement and financing issues, lower costs, increase potential for project bundling, and provide other operational improvements in energy efficiency measures.

ESCO market development can be challenging in predominantly state-owned markets, due to centralised financial management and lack of commercial incentives. In Belarus, it is expected that future ESCO market development will involve foreign investors, foreign ESCOs and foreign technology, which will require supportive legislation and regulation of foreign investment and private-public partnerships (Iqbal and Yozhikov, 2006). In December 2015, the Belarusian government adopted a Law on Public Private Partnerships, in accordance with international practices and in collaboration with the United Nations Economic Commission for Europe, the International Finance Corporation and EBRD, aimed at encouraging foreign investment. This law and supporting mechanisms on attracting foreign investment should improve the potential of the ESCO market development in Belarus in the medium term, given the effectiveness of ESCOs working in public-private partnerships.

Fuel prices and subsidies

Energy tariffs, including electricity, heat, gas and LPG are highly subsidised in Belarus. As such, consumers are unaware of the true cost of energy and are not incentivised to save. Subsidies are mainly for households, with cross-subsidies from relatively high industry tariffs. Subsidies also allow for less efficient technologies in electricity and heat generation, creating barriers to the development of new energy sources such as renewables.

At present, oil product prices in Belarus are not subsidised, but are instead taxed, as a measure for curbing demand growth. Generally fuel prices, including oil, gas and coal, influence demand at times of fluctuation, with lower prices reducing incentives for investment in energy efficiency measures and vice versa. However, given current low prices for oil, the current rate of tax is unlikely to be having any significant influence on demand, and oil product users (mainly in transport) may require other incentives for energy savings.

In the new Comprehensive Development Plan for the Electricity Sector to 2025 (approved on 1 March 2016), the government set out plans to fully phase out cross-subsidies in the electricity sector, including setting transparent and cost-reflective tariffs for production, transmission, distribution and retail sectors. Heat and gas tariffs are also being slowly phased out, although tariffs continue to achieve only a small proportion of full cost-recovery (around 20%).

On 1 January 2016 the government increased the residential tariffs for the basic consumption band for electricity, heat and gas by 20%, reflecting the abolition of an exemption from VAT (which is charged at 20%). This was the largest annual increase since the phase-out began and more than the annual increase in salaries.

Industry tariffs have remained unchanged since March 2015.

Cost-reflective tariffs and a phase-out of subsidies are highly effective ways to incentivise reductions in unnecessary energy waste and curbing demand growth. Until subsidies on all energy sources are reduced or eventually phased out, it is likely that Belarus will continue to experience energy waste, particularly in the residential and transport sectors where demand is not regulated or targeted under energy saving programmes. That said, the phase-out of subsidies will have to be managed carefully to avoid adverse impacts for sections of the population whose livelihoods depend on subsidised fuel.

1.2.2 Residential sector

The main drivers of energy consumption in the residential sector include population growth, the number of persons per household, household type and size, household income, and the type of appliances that are used in an average household.

Table 16 shows a number of demographic indicators that are some of the main drivers of energy demand in the Belarusian residential sector.

While population growth has remained fairly steady over the last five years, the average household disposable income has increased rapidly, meaning a greater capacity to purchase larger dwellings and more diverse end-uses. This is reflected in the data shown in Table 16, with average floor space per person on the rise, increasing from 24.6 square metres (m^2) in 2010 to 26.1 m^2 in 2014. In addition to an increase in the average apartment size from 78.3 m^2 to 79.7 m^2 over the five-year period, there has also been a shift towards living in standalone dwellings, trends that are likely to lead to greater residential energy use.

Table 16 also shows an increase in connections to energy services. The connection of central heating, gas and hot water supply to households has increased, with some 86.4% of dwellings having access to central heating in 2015, up from 84%. Gas connections have grown from 89.9% in 2010 to 91% in 2015. Hot water units were installed in 83.6% of households in 2015, compared to 78.3% in 2010.

CENEf (2015) estimates the technical potential of residential buildings to be around 3.0 Mtoe (around 37% of annual consumption). Potential savings through the renovation of residential buildings with centralised heating stood at around 0.7 Mtoe, and 0.3 Mtoe for the renovation of individually heated residential buildings. These estimates are higher than those of the National Energy Efficiency Programme for 2011-2015 and in the Comprehensive Programme for Design, Construction and Retrofits of Energy Efficient Housing for 2009-10 and to 2020. According to these document, weatherisation could bring 0.17-0.28 Mtoe of energy savings in residential space heating, and commissioning of at least 6 million m^2/year of energy-efficient buildings (up to 60% of the total floor space of commissioned housing) could bring another 0.1.4 Mtoe in savings (CENEf, 2015).

According to the World Bank report (2015), more than 80% of the country's residential stock was built before 1996. Building thermal protection standards were significantly strengthened in 1993 and updated in 2010. Pre-1996 buildings consume, on average, nearly twice as much energy per square metre as buildings constructed in the last four years. Deep thermal retrofits in these residential and public buildings could result in dramatic energy savings.

Table 16 • Demographic indicators that drive household energy consumption, Belarus

Indicator	2010	2011	2012	2013	2014
Population	9 481.2	9 465.2	9 463.8	9 468.2	9 480.9
Disposable income per household, BYR	1 821.8	2 747	4 948	6 649.9	8 222.6
Annual final consumption of households, BYR	106 856	168 549	298 729	383 683	469 738
Availability of housing (average per inhabitant, m^2 of total floor space)	24.6	25	25.4	25.7	26.1
Spending on housing and utilities, % of total household consumption	7	5.5	4.1	4.4	5.3
Housing stock, million m^2 of total floor space	232.9	237	240.3	243.5	247.7
Average m^2 per resident	24.6	25	25.4	25.7	26.1
Average size of apartments, m2 of total floor space	78.3	78.6	78.4	82	79.7
Household equipped with the following utilities, % of total household					
Central heating	84	84.6	85.7	86.5	86.4
Hot water supply	78.3	77.8	80.8	82.7	83.6
Gas	89.9	89.4	89.1	90.9	91

Source: BelStat (2015), *Social Conditions and Standard of Living in the Republic of Belarus*, statistical book.

Residential sector policies

The newly approved Concept of Energy Security is the key policy document for energy efficiency measures in Belarus at the moment. Planned measures to increase energy savings and improve efficiency in the residential sector are mainly in the form of a shift to energy-efficient construction and refurbishment of existing buildings. Specific measures for the residential sector under the national programme on Energy Efficiency and Energy Savings for 2015-20 include the following:

- modernisation of thermal networks, optimisation of heat supply schemes, decentralising heat with the removal of long mains
- reduction of heat network losses by 10% by 2020, through rehabilitation of infrastructure, minimum 4% of the total
- decommissioning of aged equipment
- improving insulation within building materials for residential buildings
- projects for floor heating and low-potential heat from heat pumps and solar heating
- reconstruction and modernisation of boilers with deep recycling of flue gas heat and water vapour condensation heat of the flue gas
- metering requirements and introducing individual automated heat control systems in apartments in buildings of eight apartments or more
- heat recovery devices, controlled ventilation and drains
- building small co-generation plant, solar water heaters in hot water supply systems
- energy-efficient lighting
- energy efficiency standards and labelling for appliances
- buildings certification by energy efficiency class

- energy data reporting
- public awareness and involvement of the population in energy conservation and efficiency in residential complexes.

Additionally, under the new Comprehensive Development Plan for the Electricity Sector to 2025 and Beyond, which accounts for the increase in electricity supply after the integration of the planned NPP, the government has set plans to increase the level of electrification of space heating. Specifically, during 2016 the Ministry of Architecture and Construction is expected to develop draft regulations on the introduction of systems for heating and hot water systems using electricity for heating purposes.

1.2.3 Industrial sector

Industrial sector energy demand is driven mainly by its level of activity and level of efficiency. Demand for industrial products is, in turn, largely influenced by the factors already mentioned, such as living standards and demographic changes, but also by primary industries such as mining and quarrying, as well as construction. The mining industry in Belarus is modest, while construction activity consumes a significant proportion of industrial output.

Construction activity in urban centres in Belarus experiences typical business cycles, with the strong increase in demand for households followed by price and demand readjustments and a fall in construction activity. The cycles influence demand for locally produced steel, cement (and other building materials), wood products and other energy-intensive industries. Similarly to the rest of Europe, the construction market has slumped since the global financial crisis, resulting in a decline in production of steel, building materials and wood, and an overall fall in energy demand by these industries since 2008-09. During the construction boom of 2005-10, investment in the construction industry amounted to around USD 1 billion, with financing mainly used in expanding the production of ceramic tiles, cement, granite and other building materials. The construction industry has been one of the fastest growing in Belarus over the past decade as a result (Belarus Facts, 2016).

Industry structure

The level of industry concentration, in this context the number of facilities and production concentration per facility, influences how energy efficiency policies are designed and targeted, including the feasibility of reaching facilities through audits.

The age of the industry (that is, how long the industry has been established in the country) as well as the average age of facilities within the sector, also plays a key role in energy consumption and potential for energy efficiency improvements. Newer industries and facilities, often regardless of investment size, tend to adopt more efficient technologies and are, therefore, often more energy efficient.

Belarus has over 23 000 industrial enterprises; however, it also has a high degree of production concentration. About 10% of industrial enterprises account for more than 60% of industrial output. The level of concentration is highest in the fuel industry, ferrous metallurgy, and chemical and petrochemical industries, where the share of three largest enterprises is 60% of the total sector's output (Export.by, 2016). The structure of some of the key industries in Belarus is as follows (Belarus Facts, 2016).

Building materials industry (cement, concrete, tiles, glass, bricks, coating and finish materials, etc.). The industry comprises around 1 500 enterprises with a small number of flagship enterprises and facilities. The state-owned Belarusian Cement Company is the largest producer and facility owner, accounting for around a quarter of total annual production of 5 Mt. In recent years, the four largest cement-manufacturing facilities have undergone process modernisation, resulting in capacity increase. The majority of Belarusian cement is exported, with just under half consumed locally.

Chemical and petrochemical industry. This is relatively highly concentrated. Belneftekhim accounts for over 30% of industrial production in Belarus, and constitutes 60 organisations including major refineries and fertiliser producers.[16] Belaruskali (Salihorsk) is the largest Belarusian fertiliser producer with an 11% share in the global market. Azot (Hrodna) produces nitrogen fertilisers, as well as ammonia, urea and ammonium sulphate, among others. There are a number of industrial associations that produce polyester fibres, yarns, fabrics and coatings for use in various industries. The production of high-pressure polyethylene, polyacrylonitrile fibres and organic synthesis products is the specialty of PA Polimir (Novapolack).

Food and tobacco manufacturing. The largest food manufacturing industries in Belarus include meat, dairy, confectionery, sugar, brewery and soft drinks production. The food and drink manufacturing industry is not highly concentrated, with hundreds of players in each segment of the industry. The industry is looking at modernising its processes in order to increase the production capacity for products with a longer shelf life and to manufacture niche products.

Mechanical engineering (transport equipment manufacturing). Mechanical engineering is relatively highly concentrated in Belarus. MAZ (Minsk Automobile Works) is the largest transport equipment manufacturer in Belarus, manufacturing tractors, medium-duty trucks, dump trucks, timber trucks, car chassis and many other products. MAZ produces around a third of the world's supply of tractors. Other large enterprises include the Republic's Unitary Enterprise (RUE), Republic's Unitary Production Enterprise (RUPE), Minsk Wheeled Tractor Plant, Open Joint Stock Company (OJSC) Minsk Bearing Plant and the Amkodor OJSC.

Steel and iron industry. The steel and iron complex of Belarus is highly concentrated, comprising eight enterprises that produce steel electric round and shaped tubes, steel cast blanks, rolled steel, various kinds of wire, metal cords, bolts, screws, nuts, nails, moulding materials, heating equipment, and other products. The Belarusian Metallurgical Plant in the city of Žlobin of the Homel region accounts for around 80% of total production.

Textile industry. This accounts for around 30% of non-food production, with the largest enterprises forming part of the Bellegprom complex. The Bellegprom enterprises account for around 80% of textile output, with approximately 500 textile enterprises in total.

Wood and wood products. Wood processing and wood product manufacturing accounts for around 2% of industrial production in Belarus, but is an important industry for the country. All timber and harvesting is conducted by the Bellesbumprom complex, which includes 60 enterprises. The same enterprises account for around 45% of wood furniture production in Belarus. The wood working industry has recently been partially modernised by the state, and the government is seeking new ventures in partnership with foreign investors, to expand the reach of its products to export markets.

Industrial policy

The industrial sector has undergone a programme of modernisation over the past decade, with the aim of increasing capacity and competitiveness and expanding exports. Under the national programme of modernisation, with a total budget of approximately USD 1.2 billion, a number of key facilities have been modernised, mainly in the sphere of cement, wood processing and machinery, but also in food and textiles.

[16] Petrochemical industries are not the focus of this study, which instead addresses major end-use industries.

Under the Concept on Energy Security and the National Programme on Energy Efficiency and Energy Savings for 2016-20, the following policies, targets and measures are aimed at improving industrial energy efficiency:

- a reduction of 2% in energy consumption by the manufacturing sector from 2015 to 2020
- continuation of restructuring of state-owned enterprises, and modernisation of processes
- closure of the least-efficient state-owned enterprises
- modernisation and technical re-equipment of production processes
- electrification of processes where possible, particularly in heating of facilities.

The Energy Efficiency Department monitors energy savings within the industrial sector. Enterprises plan for a reduction in energy consumption through their five-year programmes, and are financially rewarded/penalised for final outcomes. The five-year energy consumption reduction plans are based on compulsory energy audits and calculations that take into account previous five-year consumption patterns and future output and economic activity. The Law on Energy Saving requires mandatory energy audits for legal entities with annual fuel and energy consumption of more than 1 500 tonnes of coal-equivalent.

1.2.4 Transport sector

The main drivers of demand for transport include those factors already mentioned: changes in population, standards of living, urbanisation, population density and fuel prices.

Two additional factors that often drive demand for personal vehicles are the availability and the price of vehicles. Belarus is positioned between Europe and Russia in the northeast of Europe, and as such provides a transit route for road, air and pipeline transport, but also for vehicle trade. It is due to this transit route for trade that Belarus has access to a wide variety of vehicles. Additionally, Belarus's transport equipment manufacturing industry is strong, further increasing the availability of vehicles.

Table 17 shows rates of vehicle ownership in Belarus since 2000. The country has the largest vehicle ownership per capita of all CIS[17] countries: 355 per 1 000 persons in Belarus, 317 in Russia, 270 in Kazakhstan and 200 in Ukraine (Belarusian Television Channel CTV, 2016). The number of cars in Belarus has doubled over the past 15 years, and statistics show that the average age of the vehicle fleet is also falling with new car sales soaring. Five years ago, new car sales in Belarus amounted to 15 000 per year, while in 2014 the number had tripled to 45 000 (Belarusian Television Channel CTV, 2016).

Approximately half the vehicles are sold from official distributors, while the remainder are sold privately on the "grey market", estimated to be mainly imports from Russia (Focus2move, 2015). There are no duties on vehicle imports from Russia, while imports from other countries are subject to duties depending on size, age and value, as well as sales and excise duties.

Domestic manufacturing accounts for a small proportion of car sales due to its limited capacity. In 2013, some 300 vehicles were produced, representing an increase of 67% compared to the previous year. The number is expected to triple by 2016, after China's Zhejiang Geely Holding Group opened a new factory for assembling the Geely SC7 sedan in Belarus (Ernst & Young, 2013).

[17] CIS was formed when the former Soviet Union dissolved in 1991. The ten member states are Armenia, Azerbaijan, Belarus, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan and Uzbekistan; the two associate countries are Turkmenistan and Ukraine.

Table 17 • Vehicle ownership in Belarus, per 1 000 capita, 2000-14

Year	Ownership	Year-on-year % change
2014	355	1.4%
2013	350	2.3%
2012	342	1.4%
2011	337	5%
2010	321	6.2%
2009	302	6.3%
2008	284	5.9%
2007	268	7%
2006	251	6.7%
2005	235	8.3%
2004	217	3.8%
2003	209	6.6%
2002	196	4.3%
2001	188	-0.3%
2000	189	

Source: Knoema (2016), *World Daily Atlas*, www.knoema.ru/atlas, accessed on 3 May.

Transport policy

The transport sector is the third-largest energy-consuming sector in Belarus, and its demand is growing rapidly compared to the industrial and residential sectors. In its National Programme on Energy Efficiency and Energy Saving for 2016-20, the government has the following plans for improving the energy performance of the transport sector, particularly concerning the public transport fleet:

- vehicles, machinery and equipment renewal and decommissioning of aged vehicles and machinery
- installation of fuel consumption control systems, development of fuel consumption rules, and the introduction of differentiated fuel consumption rationing
- introduction of modern equipment for diagnostics, maintenance and repair of vehicles and machinery
- implementation of automated systems of dispatching control and management
- optimisation of the structure of the vehicle fleet
- increasing biodiesel consumption
- the electrification of rail systems (Molodechno-Hudahai-State border, Zhlobin-Kalinkovichi).

Further to these plans, under the Comprehensive Development Plan for the Electricity Sector to 2025 and Beyond, the government has drafted plans to increase the electrification of the vehicle fleet and build the necessary infrastructure in order to utilise the excess electricity that would come online after 2020 with the two new nuclear reactors. Plans for the development of electric vehicles are as follows, based on two scenarios:

- 30 800 electric cars and 1 880 electric buses by 2025 under the optimistic scenario (9 960 electric cars and 590 electric buses under the pessimistic scenario) by 2025
- 252 GWh of electricity usage under the optimistic scenario (78 GWh under the pessimistic scenario) by 2025

- around 1 500 charging stations (different modes) by 2025
- plans for the development of electric vehicle parts manufacturing.

If implemented, these measures are expected to result in 31.3 ktoe and 169 ktCO_2 savings under the optimistic scenario and 9.7 ktoe and 52.6 ktCO_2 under the pessimistic scenario. The plan is expected to cost in the range of USD 84-243 million and is expected to be financed by BelEnergo, local power companies, credit funds, private equity and public-private partnerships.

Vehicle standards and fleet renewal

According to UNEP (2015), Belarusian official vehicle dealers were required to meet Euro IV (heavy-duty vehicles) and Euro 4 (light duty vehicles) emission standards from 1 January 2011. Euro V/5 standards are required for vehicles produced in Belarus for export markets. On 1 January 2015, the Customs Union Technical Regulation on Safety of Wheeled Motor Vehicles came into force, which envisages Euro V/5 vehicle standards for all vehicles sold in Belarus. According to the Belarusian Transport and Communications Ministry (Glusk Regional Executive Committee, 2015), as of 1 October 2015 over 11 200 trucks were in use in Belarus, of which 60% met Euro IV and Euro V emission standards.

Belarus has 55 agreements on international transport with 44 countries, with plans to further liberalise the terms of agreement. In 2014, cargo transport permits were abolished between Belarus and Switzerland, while permits for bilateral transport, transit transport, and transport between Eurasian Economic Union member states were abolished on 1 January 2015 (Glusk Regional Executive Committee, 2015).

1.2.5 Summary of priority subsectors

Table 18 shows the priority sub-sectors and end-uses for which priority EETs should be identified for deployment. The residential, industrial and transport sectors are selected as priorities due to their significant share of total energy consumption and large potential for energy efficiency improvements. Residential and industrial demand has fallen over the past ten years; however, they are still the largest consuming sectors with significant energy efficiency potential. Conversely, demand in the transport sector has nearly doubled over the same period, and is expected to continue to grow and to increase its share of total energy demand.

End-use in the residential sector is mainly characterised by space heating, water heating, cooking and appliances, while space cooling and lighting consume a much smaller share of total residential demand. Cement/building materials manufacturing, chemical and petrochemical processing and machinery manufacturing are considered to be priority sectors due to their significant energy demand, but also the high industrial concentration and fewer large facilities. Meanwhile, food manufacturing, textiles and wood processing have low concentration and a high number of facilities, but have significant energy efficiency potential and are a focus of the government's national plans for energy efficiency investment. Road transport is the main transport mode in Belarus, and the one with the largest potential and opportunities for energy efficiency improvement.

For the purposes of restricting the length of this pilot study, the remaining steps in the methodology will be demonstrated by focusing on one subsector and end-use, namely residential buildings and space heating.

As a country with a comparatively cold climate, space heating is and will remain one of the key energy end-uses in Belarus. Space heating in residential buildings is estimated to account for around 11% of total energy demand in Belarus, which is a large share of total energy demand for one type of energy end-use. However, residential space heating is deemed to be relatively energy inefficient, with large losses and substantial potential for improvement. The building stock mainly pre-dates 1996 with poor energy efficiency standards, and the majority of dwellings consume heat without meters. Additionally, residential heat tariffs are particularly low and are cross-subsidised by higher industrial and electricity prices, reducing incentives for end-users to reduce consumption. As such, residential space heating is considered to be a priority sector for energy efficiency improvement, which is also recognised by the Belarusian government.

Table 18 • Priority sub-sectors and end-uses for analysis

	Residential	Industry	Transport
Sub-sectors:	Buildings	Cement/building materials Chemical and petrochemical Food manufacturing Textiles Machinery manufacturing Wood processing	Road transport
End-uses	Space heating Water heating Cooking Appliances	Process heating Machine drive	Passenger vehicles Buses Heavy-duty vehicles

1.3 Priority EETs

Using residential space heating as an example, the following sections document some of the steps taken to assemble a preliminary "long list" of space heating candidate technologies and then to reduce the long list to a "short list".

1.3.1 EET candidate lists

Space heating in Belarus is generally provided through district heating systems, which account for around 60% of all residential space heating. The remainder comes from individual natural gas boilers or boilers that run on fuels such as wood and coal. Around 80% of urban households are heated by district heating, while rural households mainly use individual boilers and stoves (World Bank, 2015). However, in discussions with experts in Belarus, it was noted that the country's plans to increase electrification should also be taken into account when considering possible space heating priority EETs. Therefore, in assembling a long list of candidate EETs for assessment, a broad range of space heating technologies, spanning district heating, electric heating, and building shell technologies, were collected from a range of sources, including:

- Transition to Sustainable Buildings: Strategies and Opportunities to 2050 (IEA, 2013a)
- Technology Roadmap: Energy-efficient Buildings: Heating and Cooling Equipment (IEA, 2011)
- Technology Roadmap: Energy-efficient Building Envelopes (IEA, 2013b)
- The European Commission's information and guidelines for energy efficiency labelling (EC, 2016).

1.3.2 Results of the EET screening process for prioritisation

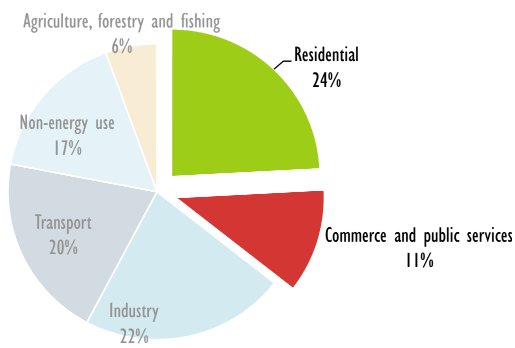
As part of this pilot study, experts from BelTEI applied the CETAM EET prioritisation screening tool (IEA, 2016) to a list of candidate EETs for each priority sector (transport, residential buildings and industry). This resulted in the identification of priority EET short lists for each sector and an assessment of their current market penetration. The full results of the EET prioritisation step are shown at Annex A.

The priority EET short list for the residential sector is shown at Figure 24, which also shows these technologies' estimated current market penetration. Results for the industrial and transport sectors are shown at Annexes B and C. Figure 24 shows a range of priority technologies that emerged, which could be applied to residential space heating, including efficient heat generation technologies, such as biomass boilers and building shell technologies such as triple-glazed windows.

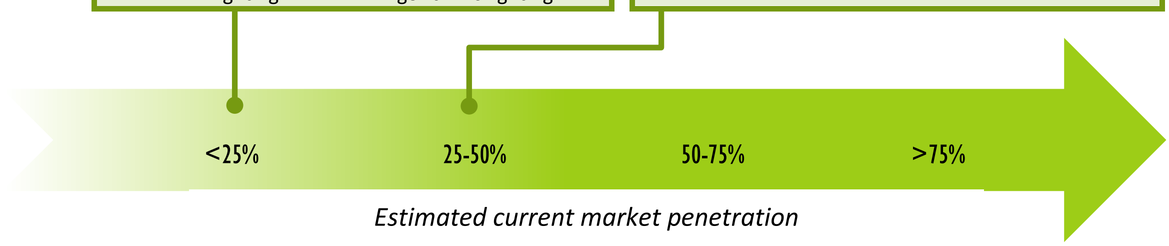
Figure 24 • Priority EETs and estimated current market penetration for the residential sector

Energy savings	End use	Technology
★★★	Space heating	Triple glazed windows
★★★	Space heating	Windows (double low-e glazing, low-conductive frames)
★★★	Space heating	Energy-plus windows in cold climates (highly insulating and dynamic solar)
★★★	Space heating	Automatic heat control systems with heat metering and data collection devices
★★★	Lighting	LED lamps
★★	Space heating	Radiators - EU labelling A++
★★	Space heating	Electric heat pumps - EU labelling - A++
★★	Space heating	Gas heat pumps - EU labelling - A++
★★	Space heating	Fully-automated biomass boilers
★★	Space heating	Pellet-fired boilers
★★	Space heating	Biomass-fired boilers
★★	Space heating	Pellet stoves
★★	Water heating	Solar water heater - EU labelling - A
★★	Water heating	Heat pump water heater - EU labelling - A
★★	Lighting	Algorithmic lighting

TFC of applicable sectors (2014)



Energy savings	End use	Technology
★★★	Space heating	Solid wall insulation
★★★	Space heating	Low-E windows
★★★	Lighting	High-Intensity Discharge Lamps (HID)
★★	Space heating	Loft insulation (100 to 200mm)
★★	Space heating	Floor insulation
★★	Lighting	Daylight sensors
★★	Lighting	Presence sensors



Estimated current market penetration

Notes: The estimated current market penetration rates and energy savings for these technologies are based on expert judgement provided by members of BELTEI and the Belarus Energy Efficiency Department.; these estimates do not represent the views of the IEA; while these technologies were identified for the residential sector, many would also be applicable in commercial and public services sector; the star ratings indicate where energy savings from deploying the technology are estimated to be high (3 stars), medium (2 stars) or low (1 star); LED = light-emitting diode; mm = millimetre.

Figure 24 also reveals that many of these technologies are estimated to have low current market penetrations, although it must be noted that a number of these technologies compete for the same end-use application (e.g. gas-based heat pumps and electric heat pumps). Although current market penetration rates are higher for certain lower-cost technology options, such as loft insulation, even these options have a significant remaining potential for deployment.

To limit the length and complexity of this paper, one technology has been selected to demonstrate the remaining steps of the methodology: automatic heat control and metering systems. For the purpose of this study, automatic heat control and metering systems are assumed to comprise thermostatic radiator valve (TRV) and heat cost allocator (HCA) retrofit packages. TRVs allow households to adjust the room temperature. HCAs are devices for allocating a building's heat consumption among different apartments proportional to actual consumption.

TRV and HCA packages have been selected as priority technologies due to their efficiency gains potential, low technical requirements, a high potential diffusion rate and the government's desire and plans to roll out these packages in residential buildings with eight or more apartments under the National Programme on Energy Efficiency and Energy Savings for 2016-20 (Table 19).

According to a report by the World Bank (2015), space heating metering exists in only 9% of households (as opposed to 95% metering of hot water systems), and heating costs are typically distributed among households based on their the floor area. Equally, just 9% of the multi-apartment buildings in Belarus have TRVs to adjust the room temperature, with TRV installations almost non-existent in pre-1996 buildings (majority of the building stock). This report suggests that HRVs and HCAs would yield energy savings of 10-15%, or 3 TWh of heat per year (World Bank, 2015).

Table 19 • Rating TRV and HCA packages against technology selection criteria

Criteria	Rating
Technical applicability	High – Technology is technically applicable to a large share of energy use within space heating and based on market structure (significant district heating penetration), while growth potential within the given infrastructure is also high
Diffusion rate	High – Fast diffusion rate is likely due to a highly horizontal technology and rapid market evolution.
Absolute savings potential	High – Large national energy savings associated with full technical adoption potential, estimated at around 10-15% per installation and a large planned number of potential installations.
Maturity	Medium – Mature technology that is commonly applied to similar sectors and end-use in international and/or domestic markets.

1.3.3 Enabling factors for market success

In addition to the criteria above, deployment of TRV and HCA packages will be affected by the broader enabling environment. A range of enabling factors should be analysed over time and these are presented under Step 3.

Step 2: Indicators, metrics and data

2.1 Identifying appropriate energy indicators

According to the established IEA recommended energy indicators (IEA, 2014), eight possible residential space heating indicators are applicable (Table 20). Belarus does not have disaggregated data on heating (space heating or water heating) in the residential sector, and is therefore at present not able to calculate residential space heating energy efficiency indicators. However, the country is expected to finalise the first household energy consumption survey in 2016, which will provide a breakdown of heating end-use in the residential sector.

Once the breakdown is made available, Belarus will be able to calculate all the energy efficiency indicators in Table 20, as necessary activity data (number of dwellings, floor area, and floor area heated) are collected at present.

Table 20 • Indicator levels for residential space heating and sources of information, Belarus

Indicator	Source of information
H1a: Total space heating energy consumption (as a share of residential consumption)	Household survey 2016
H1b: Share of each energy source in total space heating energy consumption mix	Household survey 2016
H2a: Space heating energy consumption per capita	Household survey 2016
H2b: Space heating energy consumption per dwelling (and per dwelling with heating)	Household survey 2016
H3a: Space heating energy consumption per unit of floor area (and per unit of floor area heated)	Household survey 2016
H3b: For each dwelling type: space heating energy consumption per unit of floor area (and per unit of floor area heated)	Household survey 2016
H4a: For each type of heating system: space heating energy consumption per unit of floor area (and per unit of floor area heated)	Household survey 2016
H4b: For each energy source: space heating energy consumption per unit of floor area (and per unit of floor area heated)	Household survey 2016

Source: IEA (2014), *Energy Efficiency Indicators: Fundamentals on Statistics*.

2.2 EET penetration metrics

As TRV and HCA packages are not an energy source used in heating, the most direct approach to measuring the level of penetration of this technology would be to measure a percentage of heated dwellings fitted with TRV and HCA packages.

According to the World Bank study (2015), currently around 9% of the multi-apartment buildings in Belarus have space heating meters and around 9% have traditional TRVs installed. The study does not specify whether these TRVs are accompanied by HCAs, and therefore the exact level of penetration of TRV and HCA packages is unknown, albeit expected to be below 9% of dwellings.

In order to develop the desired metric of market penetration, data on the number of installations of TRV and HCA packages can be obtained through national monitoring and/or sales data; however, it may not be easily obtainable if installations are not carefully tracked. In the absence of actual data, assumptions can be made in models using different data and analysis techniques (and in this case the total share of TRVs installed), but such analyses would need to occur on a regular basis and using consistent methods to estimate penetration on a percentage activity basis in a year-on-year fashion.

Step 3: Technology monitoring system

The monitoring of priority EET markets over time involves establishing a baseline or reference indicator value against which to measure changes in penetration and savings from the use of the technology, and then identifying sources for data collection on penetration in the priority sectors, subsectors, and end-uses.

In the case of TRV and HCA packages in Belarus, given that historical data are not available, the baseline reference indicator will become the indicator that is created once sufficient data are collected to measure the percentage of heated dwellings that are fitted with this technology. Once the baseline indicator is available, it will also be possible to track overall trends in energy indicators over time, in an attempt to better understand the link between the two. An example for Belarus would be to track the indicator on space heating energy consumption per unit of floor area (and per unit of floor area heated) alongside the selected metric for market penetration of TRV and HCA packages.

In selecting energy efficiency indicators, it is important to try and use indicators that allow the user to delineate between structural and technological changes within a country that may lead to energy efficiency savings. In order to do so, additional data would need to be collected to augment recommended indicators, such that the effects of structural change are captured.

3.1 Data collection system

There is strong interdependency between the chosen energy indicators and EET penetration metrics on the one hand, and the required data for populating those metrics on the other. Some metrics are already available in Belarus, such as the detailed analysis of the type, size and age of dwellings as well as energy balances and energy tariffs. BelStat will also finalise the first household survey on energy consumption, which will be key to developing the indicators.

Overall, it is important that the country develops a stable and consistent data collection method for tracking energy efficiency indicators and technology penetration levels, and Table 21 suggests certain elements to be considered additional to existing data.

Table 21 • Suggested data collection system for tracking market penetration of TRV and HCA packages, Belarus

Data type	Responsible entity	Collection method	Collection frequency	Quality control
Household survey	BelStat, EED	Survey of households	3-5 years	BelStat/EED
Energy efficiency indicators	BelStat, EED	Survey of households, energy balances	1 year	BelStat/EED
TRV and HCA package installations	EED	National Programme on Energy Efficiency and Energy Saving for 2016-20, implementation monitoring	1 year	EED
TRV and HCA package sales	Wholesale/retail associations	Survey of major wholesalers and retailers	2-3 years	EED
Sales information on all EETs in the residential sector	EED	Surveys of major wholesalers and retailers, surveys of households	1-2 years	EED
Cost trends for TRV and HCA packages	EED, wholesale/retail associations	National Programme on Energy Efficiency and Energy Saving for 2016-20, implementation monitoring, surveys of major wholesalers and retailers, survey of households	1-2 years	EED
Financial incentives for energy efficiency (rebates, tax reductions)	BelStat, EED	National accounts	1 year	Internal
Technology performance trends for TRV and HCA packages	EED	International best practices, energy audits	3-5 years	Internal
Consumer technology awareness and satisfaction surveys	Government institutions	Surveys	1-2 years	Internal

Source: BelStat (2015), *Social Conditions and Standard of Living in the Republic of Belarus*, statistical book.

This list is not exhaustive and will depend on the country's willingness to track a certain level of disaggregated data, as well as the resources available for collecting that data. Also, as not all data are collected at the same intervals, models are expected to be used to estimate information between collection intervals.

Under the new National Programme on Energy Efficiency and Energy Saving for 2016-20, monitoring of the programme output is expected to be done by the Energy Efficiency

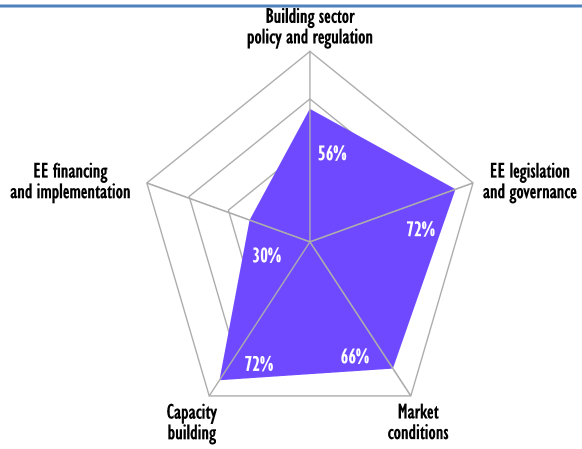
Department of the State Committee on Standardisation, through quarterly data collection, with the aim of annual reporting to the Council of Ministers. Annual reporting aims to provide information on implemented programme activities, performance target tracking, energy intensity indicator tracking and use of funds. As part of the programme monitoring, the department is expected to track the number of installations of TRV and HCA packages, as planned under the programme.

3.2 Key enabling factors for monitoring

The market penetration of TRV and HCA packages in Belarus will depend on a number of enabling factors, discussed below. The enabling environment for TRV and HCA packages would be similar across most EETs, as the overarching support mechanisms for energy efficiency improvements in the country play a significant role.

Figure 25 shows how the World Bank study (2015) rates Belarus's progress in the factors that affect the enabling environment for energy efficiency, out of a maximum score of 100%.

Figure 25 • Summary of assessment of the enabling environment for Belarus



Source: World Bank (2015), *Belarus: Scaling Up Energy Efficiency Retrofit of Residential and Public Buildings*.

Regulatory and institutional factors

The main body of legislation governing energy efficiency development in Belarus is the Law on Energy Saving (1998). According to the World Bank report (2015), the following legislation and regulation relevant to the housing stock exist at present:

- Decree on Additional Measures for Efficient Use of Fuel and Energy Resources (2003), requiring all new and renovated buildings to be equipped with individual heat substations.
- Decree on Measures to Increase Operational Efficiency of Housing Stock, Public and Social Sites and Protection of Consumer Rights of Utility Services (2003), provisioning for renovations of apartment buildings and providing technical standards for apartment-level regulation and metering of heat consumption in all new, reconstructed and renovated buildings.
- National building energy efficiency strategy (2009) by the Ministry of Architecture and Construction, setting quantitative targets for buildings energy efficiency through to 2020. It is supported by the Programme on Regulation, Standardisation and Compliance Confirmation in Energy Saving for 2011-15 and the National Housing Policy Concept (2013).
- Building Code amendments in 1993 and 2010, each increasing the thermal performance of buildings. For example, a five-floor building built before 1996 has a heat consumption standard of 169 kWh/m^2, while a new five-floor building has a standard of 48 kWh/m^2.

- EU standards for building insulation materials, and for the energy performance of windows and glass, lighting, air conditioning and refrigeration.

The legal and regulatory backbone is considered to be relatively strong; however, the monitoring of energy performance in the residential sector is lagging (while monitoring in the industrial sector is regularised). Inspections of new buildings are conducted, but consumption patterns are not monitored and data collection on buildings energy performance is limited. There are no specific requirements in public procurement rules obliging the government to purchase or give priority to products or services with higher levels of energy efficiency compared to existing standards, and no policies or regulations supporting energy savings performance contracts (ESPCs).

Despite the lack of regulation on monitoring, government sources indicate that a take-up of voluntary standards in Belarus is high, due to the growing interest in energy efficiency by the building and architectural societies.

The Energy Efficiency Department of the Standardisation Committee is the main government body implementing and monitoring energy efficiency programmes. The department implements the National Programme on Energy Efficiency and Energy Savings for 2016-20, under which a key planned measure for energy savings in the residential sector is the installation of TRV and HCA packages in buildings with eight or more apartments, where economically and technically feasible.

UNDP has been active in Belarus since 2012 through a programme entitled Improving Energy Efficiency in Residential Buildings (due to close at end-2016). Measures under the programme aim to cut energy consumption of new buildings by at least 70% compared to the building stock constructed before 1993 and by 40% compared to buildings erected in accordance with the current construction norms and thermal standards. To date, the UNDP project has helped strengthen the legal and regulatory framework and mechanisms to improve energy efficiency of new residential buildings. As a result, the first draft of the Energy Efficiency for Buildings technical regulation has been prepared in Belarus. It has also contributed to capacity building in energy audits, with seven new local companies operating in the field (out of 120 in total) (UNDP, 2016).

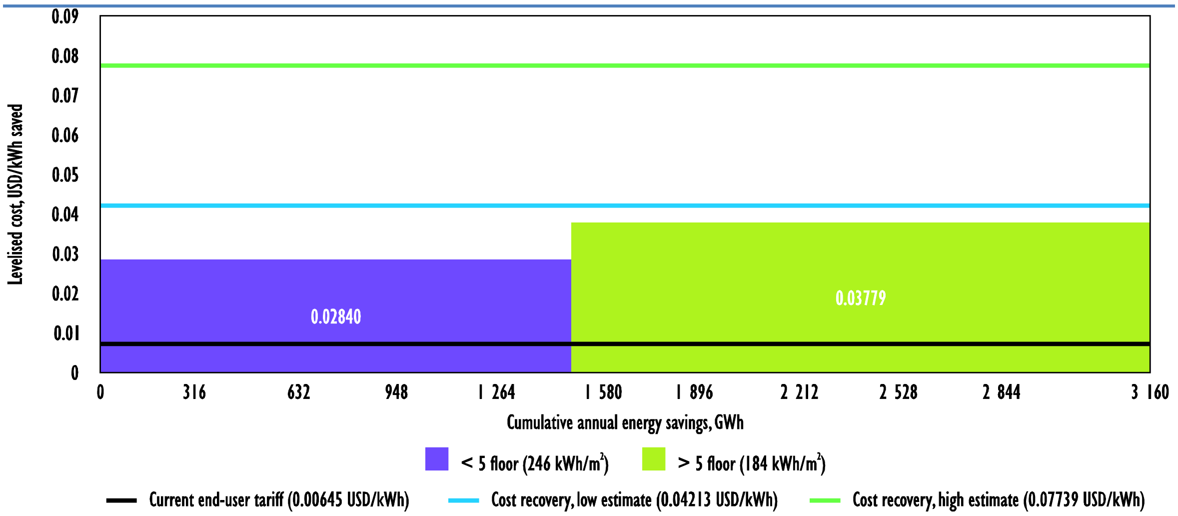
Financial and market factors

Financial and market factors for the development of energy efficiency measures and investment in EETs in the residential sector are weak at present.

Heat tariffs in Belarus are highly subsidised, being cross-subsidised from inflated industrial and electricity tariffs. The current level of cost recovery is around 20%. Low tariffs are a disincentive to energy efficiency investment and significantly increase the payback period. For example, according to the World Bank study (2015), at current tariffs, both simple and deep retrofits have payback periods well above 100 years – making it economically unfeasible at this current tariff. The study shows that payback periods could be reduced dramatically by increasing tariffs to cost-recovery level – around USD 90 per gigacalorie (Gcal) (up from around USD 10 per Gcal).

According to the same report, the levelised cost of TRV and HCA packages is higher than the current tariff (black line in Figure 26) albeit lower than the estimated cost-recovery level (blue and green lines in Figure 26). Therefore, incentives for end-users to install TRV and HCA packages do not exist at present with highly subsides prices, while the packages are financially viable in comparison to the full cost of heat supply.

Figure 26 • Levelised energy cost of TRV and HCA packages



Source: World Bank (2015), *Belarus: Scaling Up Energy Efficiency Retrofit of Residential and Public Buildings*.

There are no strong financial instruments to provide the incentive for residential building owners to invest in energy efficiency measures. The existing government programme, which provides low-interest loans to individual households to conduct various energy efficiency measures (including thermal retrofits), has a long waiting list, limited resources and is available only for low-income households in small cities. Previously, when multi-apartment buildings were selected for capital improvements, the cost of thermal retrofits was included in the scope of work and shared between the households and public sector (20% by the households, 80% by the public sector). As of 2015, the cost of thermal retrofit is still included in capital modernisation, but to a more limited extent. Public funds will be available to subsidise the renovation, but expensive thermal retrofits will be included in the renovation only if a technical review finds that defects in the building envelope have an impact on the building's structural integrity (World Bank, 2015).

Technical and infrastructure factors

The installation of TRV and HCA packages is considered to be technically feasible in most cases; however, the cost of installation will depend on the type of existing heating system in the building. Specifically, TRVs are appropriate for around 79% of multi-storey buildings in Belarus at present, excluding buildings where radiators are located within walls and renovation would be too costly (World Bank, 2015).

Social factors

Public awareness of energy efficiency benefits and the available measures and incentives in Belarus is quite limited, particularly due to low energy prices that reduce incentives for changes in behaviour. The government is committed to increasing public awareness under its National Programme on Energy Efficiency and Energy Saving for 2016-20, through the following measures:

- conducting national contests in the field of energy saving, including school projects and similar
- participating in international competitions on energy-efficient and resource-saving technologies and equipment
- a monthly publication of the scientific magazine *Energy Efficiency*
- posters, advertisements and other visual campaigning on energy savings
- seminars, conferences and round tables on energy saving themes and directions

- participation in forums and exhibitions in the field of energy saving.

Public awareness in the architectural profession and building societies in Belarus is said to be growing, with a progressive change in the design of new buildings and dwellings that incorporate voluntary standards on energy efficiency. Capacity building among professionals is also growing. A number of donor-funded programmes have built capacity among energy service providers and have introduced energy management systems (EMSs) for large energy users. Belarus also has university and training programmes on efficiency in energy and has around 30 certified energy auditing firms (World Bank, 2015).

Lessons learned from the pilot study

Data quality review

The main sources of information for the EET analysis have been IEA annual balances data for Belarus (which are provided directly from the country) and secondary research through readily available publications and Belarus's government websites (particularly for industry concentration). The Ministry of Energy, through BELTEI, has provided key supplementary information on energy policy and the latest country developments.

BELTEI was also responsible for the shortlisting of priority EETs (Annex A) and their estimated level of market penetration, based on their expertise and knowledge, and information obtained from compulsory energy audits.

During the course of the pilot study, it has been noted that Belarus's data collection and quality control is of a high standard, which has resulted in a complete set of key data for renewable energy potential and current levels of market penetration. Belarus is currently in the process of finalising its first household survey, which will allow for a development of a large number of energy efficiency indicators in the future, significantly improving the quality of residential end-use data. Before the survey results are finalised, Russia's residential sector end-use breakdown is used as a proxy.

Recommendations on future uses of the methodology in Belarus

Given that the Energy Efficiency Department has the responsibility of implementing EETs in Belarus, it is the logical agency for using the methodology in future to develop the necessary indicators and to monitor the same. BELTEI should continue to periodically (every three to five years) update the priority EET list, in order to have a full overview of the best-practice technologies and how their applicability to the Belarusian market and market penetration changes over time.

Conclusions

RETs

Belarus has substantial potential for renewables deployment, particularly in biomass, wind and solar. It also has strong strategic drivers towards more renewables, including plans to develop local energy resources and curb energy imports, and reducing GHG emissions. However, investment in this sector has been slow, due to availability of low-cost gas from Russia and lack of public awareness. At present, the Belarusian government's main focus for increasing electricity capacity is to construct a new NPP, which would significantly increase installed capacity. That said, the government continues to stress the importance of renewables, particularly as a means to diversify sources of supply. The following strengths and areas of improvement summarise some of the key conclusions reached during the pilot study.

Strengths include:

- Significant resource potential.
- Improved legislative framework regarding foreign investment.
- Generous FITs and low costs for certain technologies (particularly wood residues and landfill gas).

Suggested areas for improvement include:

- Improving the enabling environment for renewables, by removing or increasing quotas for grid-connected renewables to 2018.
- Increasing public awareness of renewables potential, particularly in state-owned enterprises where potential for smaller scale off-grid renewables is large.

EETs

Belarus, similarly to other countries of the former Soviet Union, has inherited aged infrastructure that is deemed to be highly inefficient in certain sectors. Despite this, the government puts great importance on energy savings and curbing demand growth, with demand restriction legislation and incentives-based energy savings programmes. Potential for energy efficiency remains vast, particularly in the residential sector where energy consumption monitoring has been weakest to date. The following strengths and areas of improvement summarise some of the key conclusions reached during the pilot study.

Strengths include:

- Strong government focus and dedication to energy savings – resulting in decoupling of economic growth and energy demand since the mid-1990s.
- Uptake of voluntary building standards and increasing public awareness.
- Progressive phase-out of electricity and heat subsidies over time, albeit at a slow pace.

Areas for improvement include:

- Improving energy efficiency indicators by increasing the detail of information collected through surveys, modelling and administrative data.
- Improving legislation and market conditions for the development of ESCOs.

Annex A. Results of the EET prioritisation screening methodology

The full results of the EET prioritisation screening can be found under the following link:

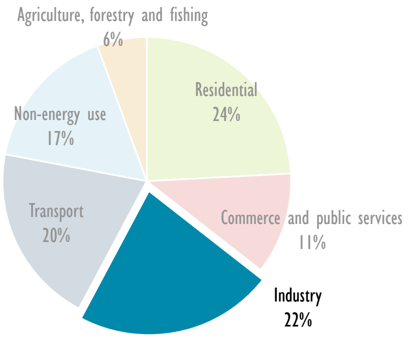
Buildings short-list for Belarus

Industry short-list for Belarus

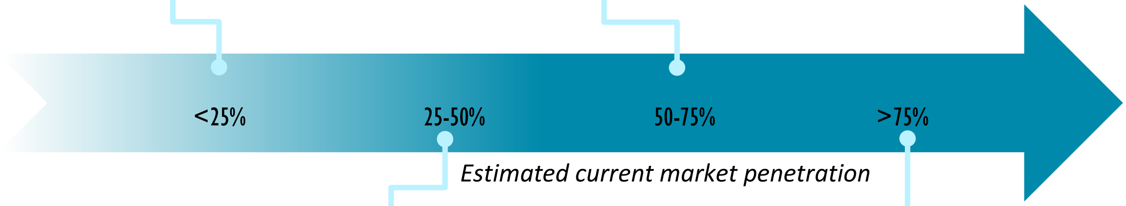
Transport short-list for Belarus

Annex B. Estimated market penetration of industry sector priority EETs

Energy Savings	End Use	Technology
★★★	Industry: Cross-cutting technologies	Flue gas heat recovery
★★★	Industry: Iron and steel	Electric Arc Furnace
★★	Industry: Food and drink manufacturing	Infrared radiation heating
★★	Industry: Cross-cutting technologies	New modes of heat transfer
★★	Industry: Transport equipment manufacturing	Electric robots
★★	Industry: Transport equipment manufacturing	Infrared paint curing
★★	Industry: Transport equipment manufacturing	UV paint curing
★★	Industry: Transport equipment manufacturing	Microwave heating
★★	Industry: Transport equipment manufacturing	Ultrafiltration/reverse osmosis for wastewater cleaning
★★	Industry: Transport equipment manufacturing	Carbon filters and other volatile organic carbon (VOC) removers
★★	Industry: Food and drink manufacturing	Membrane filtration
★★	Industry: Food and drink manufacturing	Heat pumps
★	Industry: Food and drink manufacturing	Induction heating
★	Industry: Food and drink manufacturing	Ohmic heating



Energy savings	End Use	Technology
★★	Industry: Cross-cutting technologies	Electronically controlled pumps
★★	Industry: Cross-cutting technologies	Variable speed drives
★	Industry: Cross-cutting technologies	Valve and fitting insulation
★	Industry: Cross-cutting technologies	Vent condensers



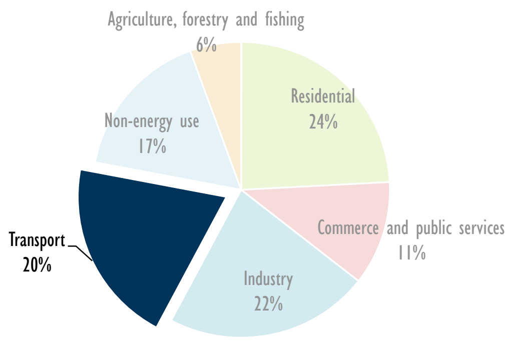
Energy savings	End Use	Technology
★★★	Industry: Cross-cutting technologies	Improved process controls (e.g. air-to-fuel ratio)
★★	Industry: Cross-cutting technologies	Efficient design burners (e.g. low NOx)

Energy Savings	End Use	Technology
★★★	Industry: Cross-cutting technologies	Feedwater economisers
★★	Industry: Cross-cutting technologies	Heat exchangers

Notes: The estimated current market penetration rates and energy savings for these technologies are based on expert judgement provided by members of BELTEI and the Belarus Energy Efficiency Department; these estimates do not represent the views of the IEA; the star ratings indicate where energy savings from deploying the technology are estimated to be high (3 stars), medium (2 stars) or low (1 star).

Annex C. Estimated market penetration of transport sector priority EETs

Energy Savings	End Use	Technology
★★★	Diesel and Gasoline ICE vehicles	Variable valve actuation and lift
★★★	Diesel and Gasoline ICE vehicles	Dual clutch transmission
★★★	Passenger vehicles	Electric vehicles
★★	HFT and MFT HDVs	Predictive cruise control
★★	MFT HDVs	Start/stop automatic
★★	Passenger vehicles	Fuel cell vehicles



Energy Savings	End Use	Technology
★★★	Diesel ICE vehicles	Advanced combustion technologies
★★★	Diesel ICE vehicles	Lightweighting (high strength steel)
★	HFT and MFT HDVs	Green zone indicators

Energy Savings	End Use	Technology
★★	HFT HDVs	Low rolling resistance tyres

Notes: The estimated current market penetration rates and energy savings for these technologies are based on expert judgement provided by members of BELTEI and the Belarus Energy Efficiency Department; these estimates do not represent the views of the IEA; the star ratings indicate where energy savings from deploying the technology are estimated to be high (3 stars), medium (2 stars) or low (1 star); HDV = heavy duty vehicle; HFT = heavy freight trucks; ICE = internal combustion engine; MFT = medium freight trucks.

Acronyms, abbreviations and units of measure

Acronyms and abbreviations

BelTEI	Ministry of Energy's Scientific Research and Project Republican Unitary Enterprise
BElSEFF	Belarus Sustainable Energy Finance Facility
BYR	Belarusian ruble
CETAM	Clean Energy Technology Assessment Methodology
CENEf	Centre Européen de Formation
CCGT	Combined-cycle gas turbine
CIS	Commonwealth of Independent States
CO_2	Carbon-dioxide
COP21	The 21st session of the Conference of the Parties to the UNFCCC
CPI	Corruption Perception Index
CSP	Concentrated solar power
DNI	Direct normal irradiance
EBRD	European Bank for Reconstruction and Development
EC	European Commission
EED	Energy Efficiency Department
EET	Energy efficiency technology
EEU	Eurasian Economic Union
EMS	Energy management system
ESCO	Energy service company
ESPC	Energy savings performance contracts
ETC	Early transition country
EU	European Union
FINTECC	Finance and Technology Transfer Centre for Climate Change (EBRD)
FAO	Food and Agriculture Organization
GDP	Gross domestic product
GDP PPP	Gross domestic product with purchasing power parity
GEF	Global Environment Facility
GHG	Greenhouse gas
GHI	Global horizontal irradiance
HCA	Heat cost allocator
IEA	International Energy Agency
INDC	Intended Nationally Determined Contribution
ICSHP	International Center on Small Hydro Power
LCOE	Levelised cost of electricity

LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
MAZ	Minsk Automobile Works
MSW	Municipal solid waste
NEA	Nuclear Energy Agency
OECD	Organisation for Economic Co-operation and Development
OJSC	Open Joint Stock Company
PPA	Power purchase agreement
PV	Photovoltaic
R&D	Research and development
RUE	Republic's Unitary Enterprise
RUPE	Republic's Unitary Production Enterprise
SEMED	Southern and Eastern Mediterranean
SWH	Solar water heater
TFC	Total final consumption
TPES	Total primary energy supply
TRVs	Thermostatic radiator valves
USD	United States Dollar
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
WACC	Weighted average cost of capital

Units of measure

bcm	billion cubic metres
Gcal	gigacalorie
GW	gigawatt
GWh	gigawatt hour
km^2	squared kilometre
kW	kilowatt
kWh	kilowatt hour
kWh/m^2	kilowatt hours per square metre
ktoe	kilo tonne of oil-equivalent
m^3	cubic metre
MWh	megawatt hour
MWht	megawatt-hour of thermal heat
m/s	metres per second
$MtCO_2$-eq	million tonnes of carbon dioxide equivalent

Mtoe	million tonnes of oil-equivalent
MW	megawatts
PJ	petajoule
TJ	terajoule
TWh	terawatt-hour

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Clean Energy Technology Assessment Methodology Pilot Study

Belarus

Belarus, like many countries around the world, faces the challenge of diversifying its energy mix and enhancing its energy security while also reducing greenhouse gas emissions. One of its priorities is to lower its heavy reliance on natural gas imports from Russia by producing more low-emission energy domestically, including renewable and nuclear power. And while Belarus has managed to decouple energy demand from economic growth, a big potential remains for improved energy efficiency due to the country's inefficient Soviet-era infrastructure and insufficient investments in energy.

Thanks to a favourable regulatory environment and a promising potential for renewables, the IEA selected Belarus for a pilot study for the Clean Energy Technology Assessment Methodology (CETAM). This methodology, developed with the European Bank of Reconstruction and Development (EBRD), aims to provide clear, transparent information about clean energy technology markets in emerging economies. The programme's goal is to identify the most promising technologies for policy support and investment and to establish metrics for tracking their deployment over time.

This report assesses the range of technological options in Belarus on both the demand and supply side to determine which show the most potential for further development, in line with the country's policy goals and resource endowment. Appropriate policies and measures that support a well-functioning market for the development of local renewable sources would help the government reach its energy security targets and reduce greenhouse gas emissions. Closer monitoring of priority energy efficiency technologies would allow Belarus to implement planned measures more effectively and optimise its energy savings potential.