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Clean Energy Technology Assessment Methodology Pilot Study

Kazakhstan

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Sonja Lekovic

INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA), an autonomous agency, was established in November 1974. Its primary mandate was – and is – two-fold: to promote energy security amongst its member countries through collective response to physical disruptions in oil supply, and provide authoritative research and analysis on ways to ensure reliable, affordable and clean energy for its 29 member countries and beyond. The IEA carries out a comprehensive programme of energy co-operation among its member countries, each of which is obliged to hold oil stocks equivalent to 90 days of its net imports. The Agency's aims include the following objectives:

- Secure member countries' access to reliable and ample supplies of all forms of energy; in particular, through maintaining effective emergency response capabilities in case of oil supply disruptions.
- Promote sustainable energy policies that spur economic growth and environmental protection in a global context – particularly in terms of reducing greenhouse-gas emissions that contribute to climate change.
- Improve transparency of international markets through collection and analysis of energy data.
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International Energy Agency
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International Energy Agency
9 rue de la Fédération
75739 Paris Cedex 15, France

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Foreword

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

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

The benefits of increasing the deployment of clean energy technologies range from mitigating the impacts of climate change to strengthening energy security and increasing economic productivity. 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.

While Kazakhstan is the largest oil producer in Central Asia, it also has the potential to become a regional leader in renewable energy development, if its ambitious targets to 2050 are reached. The government recognises the need to produce cleaner energy in order to reduce greenhouse gas (GHG) emissions and preserve its hydrocarbon resources. Renewables development to date has been modest, however, and improvements to the enabling environment and the investment climate remain central to propelling the sector forward. Kazakhstan will showcase its commitment to renewable and energy-efficient technologies at the Expo 2017 in Astana, which should become a significant stepping stone to attracting investment in this field.

On the energy efficiency side, applying CETAM shows that Kazakhstan is likely to experience growing energy demand over the medium term, and concerted support for energy efficiency will be essential to curbing demand growth and sustainable development. By deploying energy efficiency technologies, Kazakhstan, like other countries in the region, has the opportunity to “leapfrog” energy-intensive phases of development due to the availability of affordable, improved technologies.

It is my hope than 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 a 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 Early Transition Countries (ETCs)[3] of the Black Sea-Caspian region and Southern and Eastern Mediterranean (SEMED)[4] region through a combination of policy dialogue activities, technical assistance and EBRD financing, along with incentives. This IEA-EBRD collaboration is aimed at addressing the information gap related to the market penetration of climate technologies[5] in the ETCs and SEMED region.

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] 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.

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

[5] In the framework of FINTECC, "climate technologies" consist of 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.

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Executive summary

Kazakhstan's economy has developed rapidly since the country's independence from the Soviet Union, mainly through resource development and export-orientated policies. The country is the largest oil producer in Central Asia with proven crude oil reserves that are ranked the 12th highest in the world. Kazakhstan's annual oil production has boomed from around 20 Mt in the mid-1990s to a peak of 82 Mt in 2013, with plans to ramp up production to more than 100 Mt in the medium term.

Economic growth through resource development and rising living standards has driven domestic demand for energy, with energy consumption per capita increasing by 30% in just ten years to 2014. While the country is fully energy self-sufficient, growing demand has put substantial pressure on domestic producers to divert resources from lucrative exports, as well as increased the need for network infrastructure to reach outlying parts of the country. Additionally, the country emits significant greenhouse gases (GHGs) through coal and oil production but has plans to reduce these emissions by 25% in 2030 compared to 1990 (or around 1% higher than in 2012).

In order to meet these challenges, Kazakhstan has developed the Green Economic Concept to 2050, with the aim of diversifying 50% of its electricity generation from dominant coal to "alternative" fuels such as gas, nuclear and renewables, by 2050, and reducing energy intensity by 25% from 2008 to 2020. Significant investment is required to achieve these ambitious targets, made easier with the correct use of market tools and a favourable enabling environment.

To assess the market potential for clean energy technologies as well as current levels of deployment in Kazakhstan, 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 and energy efficiency technologies in Kazakhstan.

Renewable energy

Kazakhstan has significant renewables potential that remains underutilised. Vast areas with abundant sunshine are suitable for solar photovoltaics and concentrated solar power, while wind and biomass potential are also substantial in different areas of the country.

Despite the potential, the market penetration of renewable energy technologies is currently very low in Kazakhstan. Renewables account for 2.4% of its total primary energy supply, divided between biomass (1.4%) and hydro (1%). Hydro represents nearly 9% of electricity generation, while wind, solar and biomass play a marginal role. Renewables investment has been scarce to date due to limited government support until recently, technical grid connection challenges, and a lack of clarity about investment conditions.

Medium-term plans for renewables development under the Green Economy Concept include a target of 3% renewables share in electricity generation by 2020 (other than large hydro), requiring 1.8 gigawatts of additional capacity above 2013 levels. The government has made changes to the legislation to attract investment in recent years, including introducing a feed-in tariff and plans to introduce auctions of electricity from renewables.

However, more work remains to improve the investment climate, including greater clarity and transparency in grid connection rules as well as the need to rapidly implement the rules and regulation on the announced renewable energy auctions. Expo 2017 will present Kazakhstan with the opportunity to showcase its developments and commitments in the field of renewables and energy efficiency, with the hope of attracting the necessary investment. Alternatively, without such investment, Kazakhstan risks not reaching its 2050 energy resource targets and 2030 GHG targets.

Energy efficiency

Kazakhstan's final energy consumption is dominated by the industrial sector, which accounts for around 30% of total final consumption. Industrial energy demand has, however, fallen over the past decade, due to structural economic changes and the economic downturn of 2008-09. Other large consuming sectors are households, transport and commercial and public services, all of which have seen demand grow over the past decade due to rising wages and living standards.

The Kazakhstan pilot study of energy efficiency technology market penetration focuses on industry as the largest consuming sector, and more specifically on iron and steel. Steel mills represent around 34% of all industry demand. According to the Nazarbayev University's TIMES model,[6] industrial demand is expected to increase by 50% by 2030, driven by growing construction activity and higher living standards. The government is also currently undertaking a modernisation of the iron and steel industry, which is planned to result in a 50% capacity increase by 2020.

This presents an opportunity for the implementation of energy-efficient technologies, particularly those that improve existing processes. This pilot study has identified a range of priority energy efficiency technologies for deployment in the iron and steel industry. The current market penetration for the majority of the priority technologies is estimated at less than 50%, meaning that significant deployment opportunities are likely in the future.

With the strong government commitment to curbing energy demand growth and modernisation of the industry sector, Kazakhstan is well placed to implement targeted energy efficiency programmes and measures utilising global best practices, not just in industry but across all sectors. In order to attract sufficient investment in energy efficiency measures and technologies, the country would benefit from continuing to develop detailed energy efficiency indicators for monitoring progress, phasing out fossil fuels subsidies and improving legislation and market conditions for the further development of energy service companies.

[6] The TIMES (The Integrated MARKAL-EFOM System) model generator was developed as part of the IEA-ETSAP (Energy Technology Systems Analysis Program), an international community that uses long-term energy scenarios to conduct in-depth energy and environmental analyses. The TIMES model generator combines two different, but complementary, systematic approaches to modelling energy: a technical engineering approach and an economic approach.

Introduction

Project overview

Renewable energy technologies (RETs) and energy efficiency technologies (EETs), referred to from this point on as "clean energy technologies",[7] 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 greenhouse gas (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 Early Transition Countries (ETCs)[8] of the Black Sea-Caspian region and Southern and Eastern Mediterranean (SEMED)[9] region countries. 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 to directly support clean energy technologies and the wider "enabling environment" in which these policies operate, are underdeveloped (IEA, 2015a).

While there is a general understanding that deployment of clean energy technology in these regions has been low, detailed information tends to be 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[10] transfer in the ETCs and SEMED countries through a combination of policy dialogue activities, technical assistance and EBRD finance, along 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 greater 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, Caucasus, Central Asia, Southern and Eastern Mediterranean* (IEA, 2015a).

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[7] 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.

[8] 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.

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

[10] In the framework of FINTECC, "climate technologies" include 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 5 above). 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.

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 is 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 paper

The remainder of this paper is structured as follows. The rest of the introductory section provides a brief overview of the IEA Clean Energy Technology Assessment Methodology (CETAM) before outlining the purpose of the three pilot studies. In the following chapters, the results of the Kazakhstan 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.

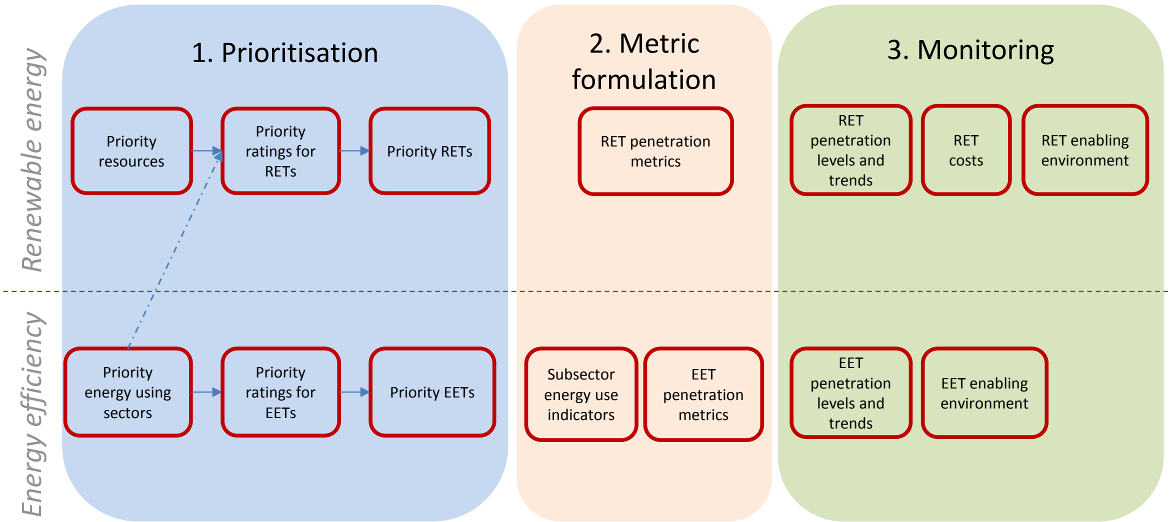
The primary users of CETAM will be the EBRD, which intends to use it as one input to inform assessment of RET and EET investment opportunities in the SEMED and ETC regions, and policy makers in the two regions, who could use it to track progress toward achieving clean energy technology deployment targets 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 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.[11] 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. 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 one mission to Kazakhstan to meet with relevant stakeholders and gather necessary information the energy sector developments. In 2016, the IEA also worked closely with the Nazarbayev University to gain information on energy balance estimates, energy consumption, forecasts and deployment of energy efficiency technologies.

[11] 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 subsector, 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 (indicators, metrics and data) and 3 (developing technology monitoring systems) are applied to *one* priority technology, as a means of demonstrating these CETAM steps. In the case of Kazakhstan, these steps were applied to scrap preheating for electric arc furnaces (EAFs) in the iron and steel industry. 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 subsector would require resources well beyond the scope of this study.

Country overview

Kazakhstan, located in the northern part of Central Asia, is bordered by Russia to the north, China to the east, Kyrgyzstan and Uzbekistan to the south, and the Caspian Sea and Turkmenistan to the west. Kazakhstan's land area is 2 717 300 square kilometres (km^2) with almost 1 894 kilometres (km) of coastline on the Caspian Sea. The capital is Astana and the country is home to 17.2 million people.

Until 2015, Kazakhstan was among the world's top ten fastest-growing economies, mainly through resource development and export-orientated policies. The country is the largest oil producer in Central Asia with proven crude oil reserves that are ranked the 12th highest in the world. Gross domestic product (GDP) declined to 1.2% in 2015 from 4.1% in 2014 due to falling oil prices and weaker export demand (World Bank, 2016). As a result, in 2015 the government announced a fiscal stimulus programme and economic reforms, aimed at boosting confidence and growth. In August 2015, the government also moved to a floating exchange rate regime and revised the budget deficit target in light of lower oil revenues from a target deficit of 3% of GDP in 2015 to 3.3% in 2016 (EBRD, 2015).

Kazakhstan improved its score in the World Bank "ease of doing business" index in 2016, ranking 41st among 189 countries (compared with 53rd in the 2015 index). The main improvements were achieved in the areas of starting business, protecting minority investors and resolving insolvency.

Kazakhstan signed a Customs Union Agreement with Russia and Belarus in January 2010. The agreement evolved into the Russia-Belarus-Kazakhstan Common Economic Space (CES) in 2012, run by the Eurasian Economic Commission (EEC) that Kazakhstan is also a party to. The CES removes barriers to free movement of goods, services, capital and labour among its members. Kazakhstan is a member of the Eurasian Economic Union (EEU), operational since January 2015, along with Russia, Belarus, Armenia and Kyrgyzstan.

Kazakhstan has joined the World Trade Organization (WTO). Kazakhstan's WTO accession protocol was signed on 23 July 2015, with the accession agreement ratified in October 2015, and on 21 December 2015 the European Union (EU) and Kazakhstan signed an Enhanced Partnership and Cooperation Agreement, aimed at boosting co-operation in a number of policy areas, including energy, transport, environment and climate change. Kazakhstan is also participating in the Chinese new Silk Road Economic Belt Initiative, after a joint declaration was signed between China and the five Central Asian countries, in June 2015.

Energy profile

Energy supply

Kazakhstan is rich in fossil fuel resources and is one of the largest energy producers in Central Asia. The country is ranked 8th highest in the world with regard to crude oil resources and 12th highest for crude oil reserves. Its natural gas reserves are 18th highest in the world.

According to Nazarbayev University's estimates of Kazakhstan's energy balances,[12] total energy production in 2014 was 154.2 million tonnes of oil-equivalent (Mtoe), an increase of 5.9% compared to 5 years prior in 2009, rising consistently over the last 15 years (with a slight downturn in 2014).

[12] This report uses Nazarbayev University's estimates of energy balances for the period 2007-14, unless otherwise stated.

Oil is Kazakhstan's most significant fuel, accounting for half of energy produced, at 82.3 Mtoe in 2014. Crude oil production was 6.4% higher in 2014 compared to 2009, as investment in infrastructure enabled more drilling. Natural gas production has grown by 10.2% from 21.2 Mtoe in 2009 to 23.3 Mtoe in 2014. Its share of total energy production was 15.1% in 2014. Coal production increased by 13% over the five years to 2014 to a share of 30.5% of total energy production. Renewable energy sources — hydro, biofuels and waste,[13] wind and solar — contributed around 1% of energy production in 2014. Production of wind energy started in 2012 while solar energy production began in 2013.

Total primary energy supply (TPES)[14] was 71.6 Mtoe in 2014, about 46% of the energy produced, while the rest was exported. Fuel shares in TPES were: 49.3% coal; 28.9% natural gas; 19.7% oil; 2.4% renewables; and 0.3% net electricity exports. TPES rose by 24.9% over the five years to 2014, growing at a faster rate than energy production.

Electricity generation totalled 9.39 terawatt hours (TWh) in 2014. The vast majority of power generation is from coal-fired power plants, concentrated in the north near the coal-producing regions. Coal accounted for 72% of electricity generation, with 19.2% from gas and 8.8% from hydro. There are 71 power stations in Kazakhstan, including 5 hydropower plants. This represents an installed electricity capacity of approximately 19 400 megawatts (MW), with 15 300 MW available capacity.

Energy demand

Total final consumption (TFC)[15] was 39.1 Mtoe in 2014, which is 34.5% higher compared to 2009. Industry is the largest consuming sector, representing 29.5% of TFC in 2014, followed by the residential sector (27.1%) and transport (21.5%). The commercial and public services sector consumed 16.3% of TFC in 2014, while the remainder was consumed in non-energy use (3%)[16] and agriculture and forestry (2.5%).

Kazakhstan's energy intensity, measured as the ratio of TPES to real GDP, was 0.18 tonnes of oil equivalent (toe) per USD 1 000 GDP at 2010 prices, with purchasing power parity (PPP) in 2014. This is a similar level to other countries in the former Soviet Union in comparable climates. Since 2009, energy intensity in Kazakhstan has declined by 6.8%, down from 0.20 toe/USD 1 000 GDP PPP. Energy intensity has been declining since the mid-1990s.

Energy-related carbon dioxide emissions

Kazakhstan's total GHG emissions were 283.6 million tonnes (Mt) in 2012, more than 20% below 1990 levels. Around 85% of the GHG emissions in 2012 were from the energy sector (UNFCCC, 2015). Kazakhstan's energy-related carbon dioxide (CO_2) emissions totalled 244.9 Mt in 2013, 3.2% lower than in 1990. The power generation sector accounted for 36.3% of emissions, followed by manufacturing (28.5%), refining and other energy industries (20%), transport (5.6%), residential (4.5%), commercial and public services sector (2.8%), agriculture/forestry (0.8%) and 1.3% non-specified.

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

[14] 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.

[15] 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.

[16] 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.

Energy policy framework

The Kazakh government launched the Kazakhstan 2050 Strategy in 2012, which defines the course for long-term economic development. In May 2013, the Green Economy Concept was adopted, setting an ambitious target by 2050 of 50% of the electricity generation mix to comprise energy sources "alternative" to coal and oil, including gas, nuclear and renewable energy.[17] The government plans to achieve this by phasing out ageing infrastructure, increasing the use of these "alternative" fuels, installing efficient energy technologies and complying with high ecological standards.

The Kazakhstan 2050 Strategy includes social, economic and political reforms with the aim of placing Kazakhstan in the top 30 global economies by 2050. Economic growth is to be achieved by reaching new export markets, improving the investment climate and further developing the private sector as well as public-private partnerships. The Ministry of National Economy was established in early 2013 to promote social and economic development, while a number of ministries merged to form the newly established Ministry of Energy, in charge of overall energy sector policy and implementation, except for energy efficiency, which remained under the responsibility of a restructured Ministry of Investment and Development.

Under the Green Economy Concept the government plans to optimise hydrocarbon exploration while observing environmental standards for sustainable exploitation of natural resources. In addition to a target of 50% of Kazakhstan's electricity to come from alternative sources by 2050, other targets include:

- reducing energy intensity (per unit of GDP) by 10% by 2015 and by 25% by 2020, from 2008 levels
- resolving drinking water supply restrictions by 2020 and agricultural water supply by 2040
- increasing agricultural land productivity by a factor of 1.5 by 2020.

The Ministry of Energy inaugurated the Green Academy in mid-2013 to develop the Green Economy Concept and related strategic approaches. Feed-in tariffs for wind, solar, small hydro and biogas were introduced in June 2014, under a new Law on Supporting the Use of Renewable Energy Sources and with support from the EBRD.

In 2015, President Nazarbayev introduced Kazakhstan's "100 Concrete Steps" programme, aimed at boosting transparency and accountability using structural reforms by: 1) creating a professional government apparatus; 2) ensuring rule of law; 3) improving industrialisation policy and promoting growth; and 4) creating a transparent, accountable state. As part of the programme, the capital city, Astana, will be developed as a new international financial centre to be created on the site of the Astana Expo 2017. The government has also introduced reforms to support a favourable investment climate; in particular rules for the establishment of a one-stop shop for investors were adopted in February 2015, and the law on investments was amended in December 2014 to help improve the investment climate, supported by a liberalised visa regime.

Kazakhstan signed and ratified the Kyoto Protocol in 2009. Under the 2009 Copenhagen Accord, Kazakhstan proposed to reduce emissions to 15% below 1990 levels by 2020. Kazakhstan 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 GHGs by 15-25% by 31 December 2030, compared to 1990. The target of 15% is unconditional while the 25% target is conditional on access to additional international investments, low-carbon technology transfer

[17] Coal currently accounts for around 72% of electricity generation in Kazakhstan. According to the Decree 557 of the President of Republic of Kazakhstan (2013), "alternative fuels" are defined as all energy sources other than coal used in electricity generation towards the achievement of the diversification target.

mechanisms, green climate funds and flexible mechanisms for countries with economies in transition (UNFCCC, 2015). The unconditional target would be equivalent to an increase in emissions of 13% in 2020 compared to 2012 and a 1% increase in 2025 and 2030 compared to 2012 (Climate Action Tracker, 2016).

Kazakhstan approved its emissions trading scheme (ETS) in 2011. In Phase I (2013) the cap was set at 147 million tonnes of CO_2 ($MtCO_2$) (plus a reserve of 20.6 $MtCO_2$), equivalent to 2010 levels. In Phase II (2014-15) the cap was set at 155.4 $MtCO_2$ in 2014 and 153 $MtCO_2$ in 2015, representing reduction targets of 0% and 1.5% respectively, compared to the average CO_2 emissions of capped entities in 2011-12. The Phase III (2016-20) cap is set at 746.5 $MtCO_2$ (plus a reserve of 21.9 $MtCO_2$). The first two phases included free allowances, while auctioning may be introduced in Phase III. ETS Legislation on the third phase is still pending and key provisions are currently suspended until 1 January 2018 while legislative amendments are being developed that aim to enhance the effectiveness of the mechanism (ICAP, 2016).

Results of the pilot study for RETs

Step 1: Prioritisation of RETs

1.1 Renewable resources

Renewables potential in Kazakhstan is considered to be huge albeit no detailed and reliable feasibility studies were found that measure the renewable energy resources in the country. In this report, estimates are based on data provided by KazEnergy (2015). However, data from other sources (including UNDP, 2016a) differ substantially with those provided by KazEnergy. Given the wide variation in estimates, it is strongly recommended that further studies are carried out in order to assess the technical and economic potential of renewable resources.

Different types of resources and their quality and level of assessment are discussed below.

Bioenergy

Bioenergy (biomass, biogas and biofuels)[18] potential in Kazakhstan is estimated to be substantial, as forestlands cover 10 million hectares (MHa) or 4% of the country's territory, of which 4.7 MHa are covered by saxaul bushes.[19] The energy potential of timber waste (to create biomass) is estimated at 1 Mt or 2.3 TWh. Additionally, 20% of overall straw production could produce up to 87 gigawatt hours (GWh) of energy (Aliaskarov, 2012; Energy Partner, 2016).

Kazakhstan has 76.5 MHa of agricultural land and 185 MHa of steppe grasslands, providing large biomass wastes and residues. The country produces and exports crops such as wheat (winter and spring), rye (winter), maize (for grain), barley (winter and spring), oats, millet, buckwheat, rice and pulses, with an average grain yield of 17.5-20 Mt per year, which equates to roughly 12-14 Mt of biomass wastes. Organic wastes are also a potential source of energy and at least 400 000 households are known to keep cattle, horses and sheep. It has been estimated that Kazakhstan's electricity generation potential from biomass is 35 TWh per year and heat generation potential is 4.4 Mtoe per year (Karatayev and Clarke, 2015). Potential methane sources from cattle waste are estimated at 85 000 tonnes, or more than 52 000 toe. Potential sources of methane from the treatment of sewage at communal utilities comprises about 3 000 tonnes or almost 1 800 toe (Energy Partner, 2016).

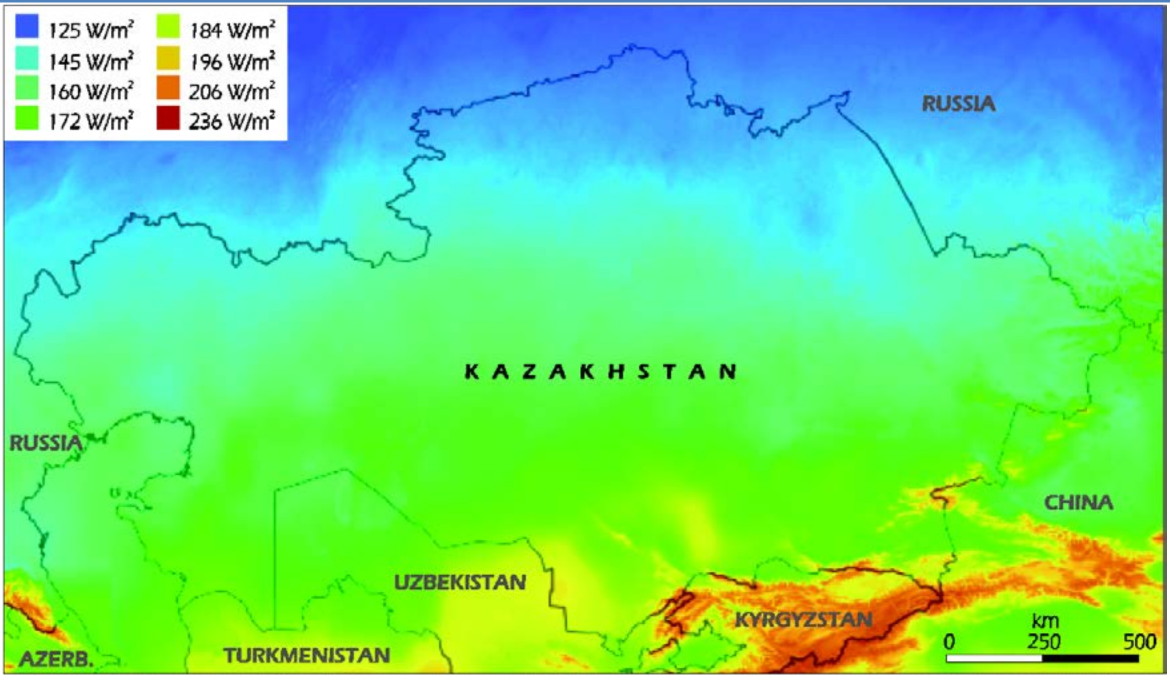
Solar

Kazakhstan's solar energy potential is expected to be significant, due to an approximate 3 000 hours of sunlight a year and the energy of solar radiation at around 1 300-1 800 kilowatt hours per square metre (kWh/m^2) per year. KazEnergy (2015) estimates the theoretical potential at 3 700 000 TWh a year, which requires further studies in order to establish the technically and economically feasible resource. Both thermal concentrated solar power (CSP) and solar photovoltaic (PV) have potential. Figure 2 shows the mean annual solar radiation (W per m2).

[18] For the purpose of this 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.

[19] Saxaul (Haloxylon ammodendron) is a bushy plant common in sandy and dry environments in Southwest and Central Asia).

Figure 2 • Horizontal solar radiation on the territory of Kazakhstan



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: Vaisala, Global Solar Dataset 3km with units in W/m², extract from the IRENA Global Atlas for Renewable Energy webpage, http://irena.masdar.ac.ae/ (accessed 7 September 2016).

Wind

Kazakhstan's wind power potential is considered to be very large. Around 50% of Kazakhstan's territory has average wind speeds of about 4-5 metres per second (m/s) at a height of 30 metres (m) and about 10-15% of the country has average wind speeds of over 6 m/s. KazEnergy estimates the wind potential at 14 098 TWh per year, spread across the country (Figure 3) (KazEnergy, 2015). With a density of wind capacity of about 10 MW per km^2, the potential exists to install thousands of megawatts of wind farms in Kazakhstan (REEEP, 2016). The most promising sites are considered to be in the Almaty region, in the Djungar (Dzhumgarian) Gates and the Chylyk Corridor. Wind potential of 525 watts per square metre (W/m^2) in the Djungar Gates and 240 W/m^2 in the Chylyk corridor have been estimated, with power production from wind turbines potentially achieving 4 400 kilowatt hours per MW (kWh/MW) and 3 200 kWh/MW respectively. Table 1 shows the wind sites with the greatest potential in Kazakhstan (Karatayev and Clarke, 2015).

Table 1 • Prospective regions for wind power development in Kazakhstan

Location of potential wind farms	Region	Projected installed capacity (MW)	Annual production (TWh)
Mangystau Mountains	West	210	0.4
Peak Karatau	South	190	0.23
Chu-Ili Mountains	South	180	0.27
Mount Ulutau	Central	90	0.13
Yerementau Mountains	Central	50	0.01
Mugojary Mountains	West	10	0.01
Djungar Gates	South	200	0.66
Total		930	1.71

Source: Karatayev, M. and M. L. Clarke (2015), "A review of current energy systems and green energy potential", *Renewable and Sustainable Energy Reviews*, Energy Technologies Research Institute, www.elsevier.com/locate/rser.

Figure 3 • Background zoning of average annual wind speed, Kazakhstan

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.

Geothermal

Kazakhstan's geothermal potential stems from a large resource of middle- and low-temperature thermal water. The geothermal reservoirs with the greatest prospects are in Cretaceous formations in the South and Southwest (Energy Partner, 2016). KazEnergy estimates the potential of geothermal energy to be 38 TWh (KazEnergy, 2015).

Total thermal water resources are estimated as 520 megawatt thermal (MW_{th}) (free-flow operation) or 4 300 MW_{th} (pumping operation). So far, proven resources for electricity production (Panfilov field) are 12 MW from the Cretaceous aquifer (Energy Partner, 2016).

Hydropower

Kazakhstan's hydropower potential is estimated at about 170 TWh per year, of which 62 TWh is technically feasible and 27 TWh is economically feasible (KazEnergy, 2015). Hydro resources are concentrated in three main districts: the Irtysh River basin with its main tributaries (Bukhtarma, Uba, Ulba, Kurchum and Kardzhil); the Southeastern zone with the Ili River basin; and the Southern zone with the basins of the Syrdaria, Talas and Chu rivers (Figure 4) (REEEP, 2016).

Figure 4 • Map of hydropower resources in Kazakhstan

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: KazEnergy (2015), "KAZENERGY National Energy Report", presentation, www.kazenergy.com/images/stories/ob_association/national_energy_report_general_director_a_magauov_en.pdf.

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. CETAM (IEA, 2016) contains details of this procedure and the underlying assumptions.

For this study, the IEA has estimated likely cost ranges for renewable energy generation, shown in Table 2 and Figure 5, using eight renewables classifications. Financing conditions in Kazakhstan are affected by poorer international credit ratings and high inflation levels. IEA therefore estimates that the underlying cost of capital would be relatively high, at around 15%.

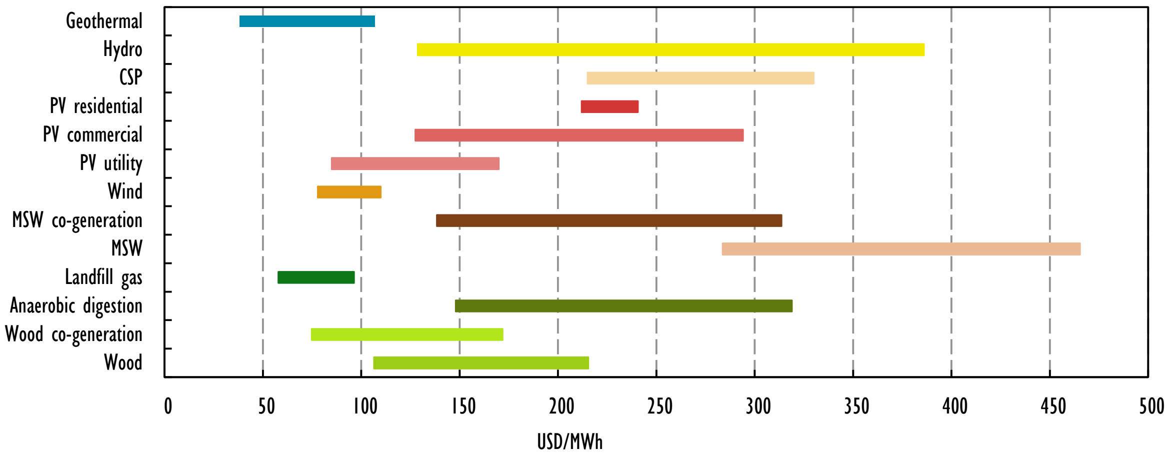
Table 2 • Likely cost range for renewable energy generation, Kazakhstan

Category	Comment	Ranking	Likely range of costs, USD/MWh	
Wood and agricultural residues	Extensive forestry and agricultural materials available	Good to moderate	Electricity only	106-215
			Co-generation	75-172
			Co-firing with coal	85-126
Municipal solid waste (MSW)	In spite of good resource availability, waste management legislation and policies do not provide adequate incentive for waste-to-energy projects	Poor	Electricity only	284-465
			Co-generation	138-314
Landfill gas		Good		58-96
Biogas (anaerobic digestion)	In spite of good resource availability, waste management legislation and policies do not provide adequate incentive for	Poor	Electricity only	169-365

	waste-to-energy projects			
Wind	Some areas of good wind regime	Good	Utility	78-110
Solar PV	Some areas of good solar regime	Good	Utility	85-170
			Commercial	127-294
			Residential	120-241
CSP	Some areas of CSP potential in Southeast Kazakhstan	Fair		215-300
Hydro	Some promising sites	Fair		129-386

Notes: *Co-generation* refers to the combined production of heat and power; MSW = municipal solid waste; MWh = megawatt hour.

Figure 5 • Indicative renewable energy generation costs, Kazakhstan



Note: Costs are indicative and ranges reflect differences in resources and local conditions. For comparative purposes, the publication *Projected Costs of Generating Electricity 2015*, (NEA/IEA/OECD, 2015) examines the levelised cost of electricity generation in more than 20 OECD member and non-member countries.

1.3 Technology maturity and ambition

All technologies deployed in Kazakhstan at present are mature and have commercial status, according to Table 6 in the methodology paper (IEA, 2016). Kazakhstan has no ambition to pursue technologies that are in the early stages of development, such as offshore wind or wave technologies – nor does it have the potential to do so.

The energy sector is one of the key areas of research and development (R&D) in Kazakhstan. In 2011, the US Lawrence Berkeley Laboratory, under a contract with the Nazarbayev University, developed a Centre for Energy Research for joint research projects. The Centre for Energy Research falls within the larger Nazarbayev University Research and Innovation System (NURIS). As well as researching carbon storage and energy efficiency, the centre also conducts research into renewables, mainly focusing on solar cells (Lawrence Berkeley Laboratory, 2011), including:

- pure organic solar cells, based on new kinds of light-absorbing organic pigments with improved electronic properties, which are also low cost, non-toxic, abundant, stable and highly soluble for cost-effective assembly
- low-cost, solid-state, dye-sensitised cells, made using new laser techniques to simplify the manufacturing process of existing titanium-dioxide thin film devices while adding a layer of new organic dyes to improve their electronic performance
- optimising solar cell structures on the nanoscale through nano-imprint technology
- large-scale, low-cost production of carbon-based transparent conductor films made with graphene sheets and carbon nanotubes.

1.4 Strategic priorities

Kazakhstan's economy has developed rapidly over the past two decades, largely due to the boom in oil exploration and exports. Energy demand has increased by 50% over the ten years to 2014, and is expected to continue to grow albeit at a slower rate (caused by slower growth in GDP resulting from lower oil prices). Nonetheless, as demand grows and the standard of living improves, the strain on the energy sector will intensify, with additional pressure on the exploration industry to supply to domestic markets rather than more lucrative export markets.

Kazakhstan is self-sufficient in energy at present, and a significant exporter of oil and coal. However, KazEnergy (2015) projects that by 2030 Kazakhstan could become a net importer of oil products, taking account of the fall in production in recent years. The potential start of the Kashagan field, planned for October 2016, would ease some of the increasing demand pressures and even invert current trends if other fields become active.

Climate change is one of Kazakhstan's major challenges, as its geographical position is highly exposed to climatic changes. The government is committed to reducing GHGs, with its latest commitment of an unconditional 15% reduction by 2030 compared to 1990, and a 25% reduction conditional on the availability of international investment and access to a low-carbon technology transfer mechanism, green climate funds and a flexible mechanism for countries with an economy in transition (KazEnergy, 2015). Coal use is one of the largest contributors to Kazakhstan's emissions, accounting for 60% of CO_2 emissions in 2013.

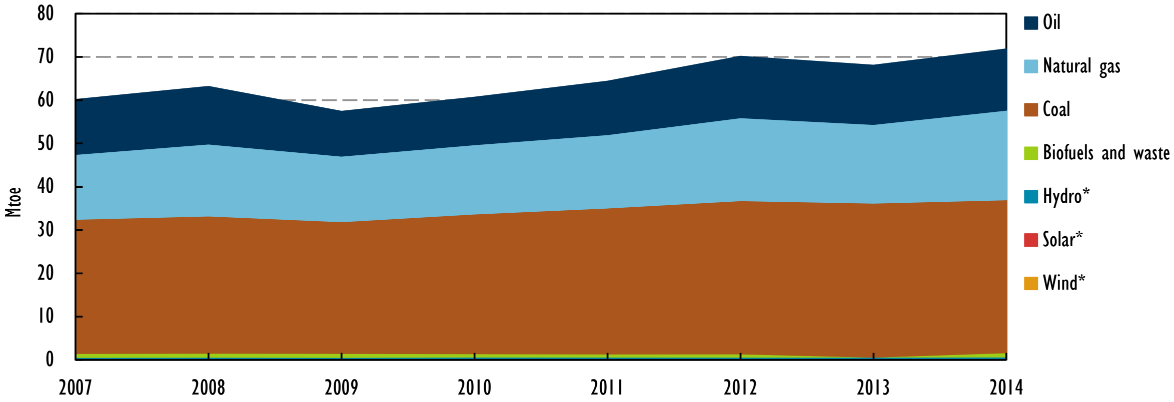
A key strategic priority for the Kazakh government is the diversification of electricity generation. In May 2013, the government adopted the Green Economy Concept, setting an ambitious target by 2050 of 50% of electricity generation to comprise of energy sources "alternative" to coal and oil, notably including renewables. Currently renewables account for less than 10% of electricity generation with hydropower alone accounting for 8.8%. Over time, renewables can also contribute to a reduction in oil demand in transport and industry, allowing for a curb in oil production or an increase in more lucrative exports.

1.5 Market opportunities

Kazakhstan is self-sufficient in energy as a significant producer of oil and coal and a significant exporter of both. In terms of domestic demand, coal represented 49.3% of TPES in 2014, with natural gas at 28.9% and oil at 19.7% (Figure 6). Together, fossil fuels accounted for 97.9% of domestic supply. Natural gas has experienced the strongest growth in supply, increasing by 36.6% from 2009 to 2014, due to significant network developments. The supply of coal and oil grew by 16.1% and 10%, respectively, over the five years. Renewables represented 2.4% of the energy mix in 2014, namely hydro 1% and biofuels and waste 1.4%. Wind and solar power generation was negligible in comparison.

As a country with a large territory and dispersed population, Kazakhstan imports oil, coal and gas, despite also being a significant producer. In 2014, Kazakhstan imported 58% of its total oil supply, mainly in oil products and some crude. Gas imports accounted for 40.5% of supply, while coal imports were only 2% of supply.

Figure 6 • TPES, Kazakhstan, 2007-14

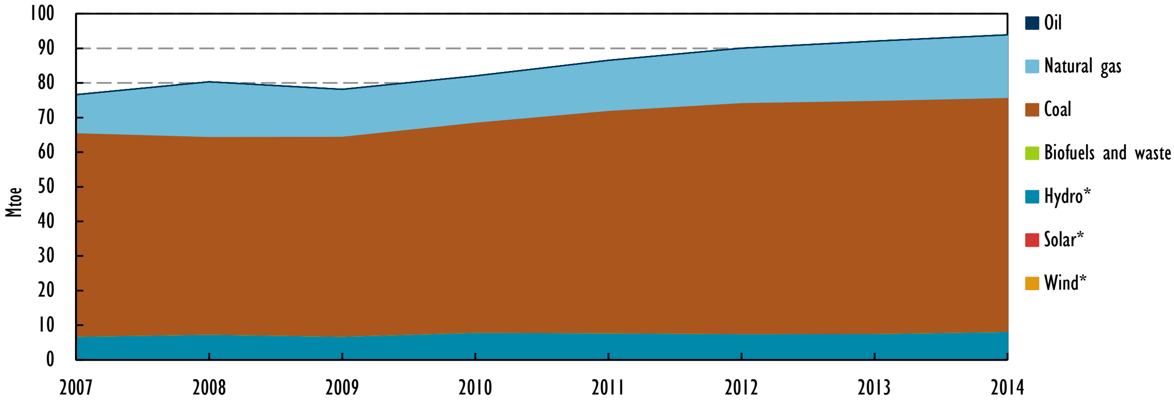


* = Negligible.

Source: Nazarbayev University (2016), "Kazakhstan energy balances for 2007-14", submission to the IEA.

Electricity generation totalled 93.9 TWh in 2014 (Figure 7) and is fuelled mainly by coal (72% of total fuel use), with the remainder coming from natural gas (19.2%), hydro (8.8%) and negligible wind, solar and oil. Over the five years to 2014, coal consumption in electricity generation increased by 17%, while natural gas consumption grew by 33.6%. Electricity from hydro was 20% higher in 2014, albeit with large fluctuations year-on-year.

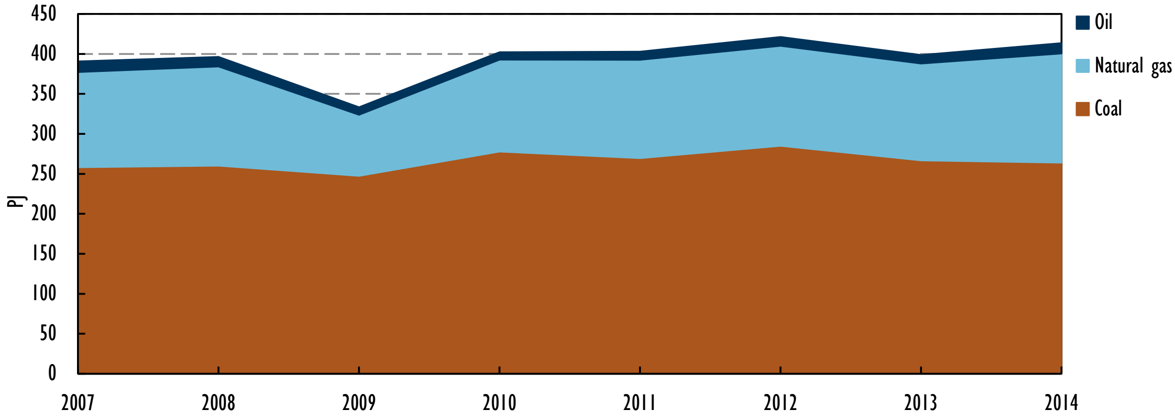
Figure 7 • Electricity generation by source, Kazakhstan, 2007-14



* = Negligible.

Source: Nazarbayev University (2016), "Kazakhstan energy balances for 2007-14", submission to the IEA.

Figure 8 • Heat generation by source, Kazakhstan, 2007-14

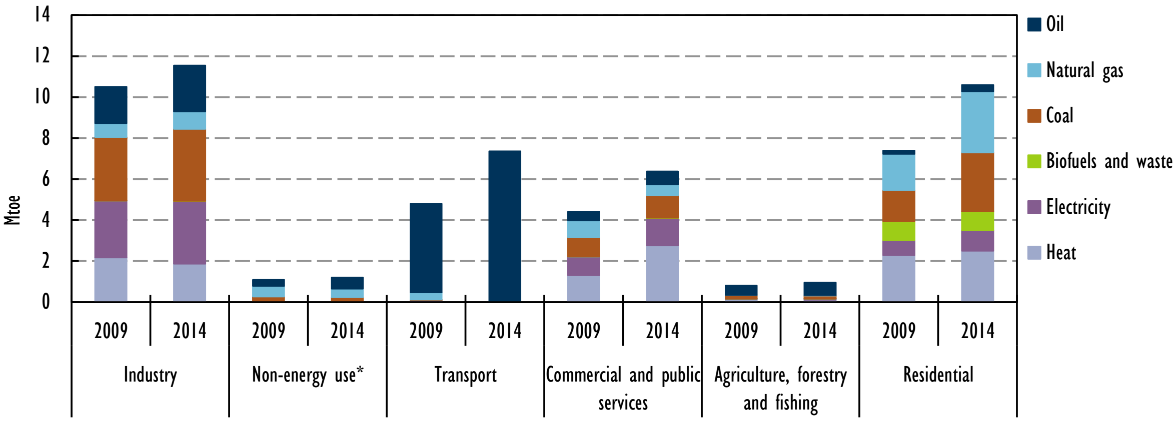


Source: Source: Nazarbayev University (2016), "Kazakhstan energy balances for 2007-14", submission to the IEA.

Heat output amounted to 413.7 petajoules (PJ) in 2014 (Figure 8) and was generated from coal (63.8%), gas (33%) and oil (3.2%). Heat generation was 24% higher in 2004 compared to 2009.

Looking at demand-side factors, the largest energy-consuming sector is industry, accounting for 29.5% of demand, followed by the residential sector with a 27.2% share. Transport accounted for 21.5% of total demand in 2014, while the commercial and public services sector consumed 16.3%. Agriculture, forestry and fishing and non-energy use consumed 2.5% and 3% of total final demand, in that order (Figure 9).

Figure 9 • TFC by sector by source, Kazakhstan, 2009 and 2014



* = Non-energy use comprises fuels used as raw materials.

Source: Nazarbayev University (2016), "Kazakhstan energy balances for 2007-14", submission to the IEA.

Figure 9 shows that the main fuels used in industry are coal, oil and electricity. Coal consumption in industry is mainly attributed to autonomous heat and electricity production. Industry demand has experienced strong growth, with a faster increase in coal and oil consumption as compared to heat (indicating that industry is turning more to autonomous heat generation).

In the residential sector, heat, coal and natural gas are the largest sources of energy. Coal and natural gas use in households has grown considerably over the ten years to 2014. The commercial and public services sector is also a major heat consumer, with significant use of coal, oil, electricity and natural gas.

The sectors with fastest-growing energy consumption in Kazakhstan are residential, followed by transport and the commercial and public services sector. Residential sector demand was 293% higher in 2014 compared to 2004, while transport and commercial and public services sector demand increased by 48% and 34%, respectively.

Renewables are currently consumed mainly in the residential sector, namely biomass that represents 8.7% of total residential demand. Some biomass is also used in the commercial and publics services sector, albeit only 0.2% of total demand.

Conclusions on market opportunities

Given the current energy mix and consumption trends in Kazakhstan, and strategic priorities to reduce CO_2 emissions and diversify its energy mix, the main market opportunities for renewables are:

- Grid-connected electricity: to contribute to reducing coal and gas use for power generation, so reducing import dependency, improving diversification, and GHG emissions through expansion of hydro, wind and solar PV generation.

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

A potential competitor to renewables development in Kazakhstan are new offshore oil and gas field developments (primarily Kashagan), as well as the government's stated priority of building new nuclear power reactors. Nuclear power developments have been discussed for a decade, without significant progress; however if new capacity were to be built, it could have an impact on the enabling environment of the deployment of renewables, depending on the size of the new capacity. Additionally, the government is planning to increase access to gas for certain regions of the country, which could potentially affect the enabling environment for the deployment of renewable alternatives (such as biomass district heating or solar heating).

1.6 Summary of priority RETs

The information above indicates the existence of strong strategic drivers to diversify the energy mix through increased deployment of renewable energy technologies. Renewable energy sources are considered to be vast, albeit further studies are necessary for the full potential to be calculated.

Table 3 is a matrix ranking RETs against the main priority determinants, highlighting the main priority technologies for the government of Kazakhstan.

Table 3 • Matrix of priority indicators for RETs in Kazakhstan

Technology	Resource	Strategic drivers	Market opportunities	Technology maturity	Cost	Priority score
Rooftop PV	★★★	★★★	★★★	★★★★	★★	Ready for deployment
Large-scale solar PV	★★★	★★★	★★★	★★★★	★★★	Ready for deployment
Large-scale solar CSP	★★★	★★★	★★★	★★★	★★	Ready for deployment
Solar water heaters	★★★	★★	★★★	★★★★	n/a	Need further evaluation
Wind	★★★	★★★	★★★	★★★★	★★★	Ready for deployment
Bioenergy	★★★	★★★	★★★	★★★★	★★	Ready for deployment
Geothermal	n/a	n/a	n/a	★★★★	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).

Step 2: Indicators, current penetration and costs

2.1 Indicators and current levels of market penetration

Table 4 shows current RET capacity in Kazakhstan for technologies where data are available through public sources or discussions with the government and Nazarbayev University.

Table 4 • Current RET capacity levels in Kazakhstan

Renewable energy source	Capacity MW
Biomass (wood, waste and agricultural)	..
Wind	70
Biogas	0.4
Small hydro	125
Large hydro	2 535
Solar	57
Geothermal	..
Total*	**2 787.4***

* = Summary of available data.

Note: .. = value not available.

Sources: Karatayev, M. and M. L. Clarke, (2015), "A review of current energy systems and green energy potential", *Renewable and Sustainable Energy Reviews*, Energy Technologies Research Institute, www.elsevier.com/locate/rser; Embassy of the Republic of Kazakhstan to the United States (2016), "Renewable energy in Kazakhstan: More than 1 GW until 2020", webpage, www.kazakhembus.com/content/renewable-energy-kazakhstan-more-1-gw-until-2020, accessed on 1 May; Azernews (2016), "Kazakhstan ups energy production from renewable resources", press release, 22 February, www.azernews.az/region/93219.html. Ministry of Energy (2016), website, energo.gov.kz/index.php?id=5472, accessed on 11 July.

Hydropower accounts for approximately 13% of Kazakhstan's total generating capacity, comprising 2 535 MW of large hydro and 125 MW of small hydro. The large hydropower plants are: the Bukhtyrma (750 MW), Shulbinsk (702 MW) and Ust-Kamenogorsk (315 MW) plants on the Irtysh River; the Kapshagai (364 MW) plant on the Ili River; the Moinak (300 MW) plant on the Charyn River; and the Shardarinskaya (104 MW) plant on the Syrdarya River (Karatayev and Clarke, 2015) (Embassy of the Republic of Kazakhstan to the United States, 2016).

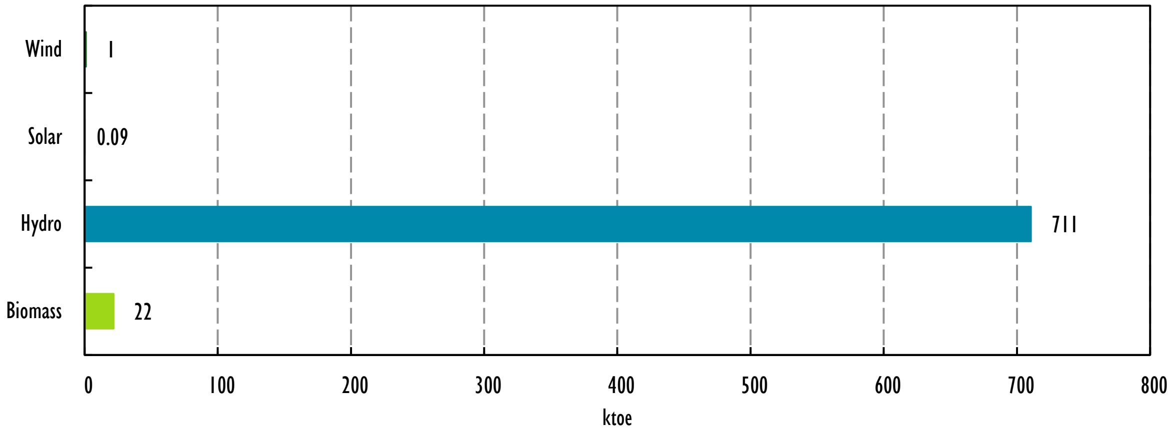
One large-scale biogas unit is currently in operation in Kazakhstan, in the Vostok village in the Kostanai region, with a capacity of 360 kilowatts. The Vostok biogas unit consists of two 2 400 cubic metre (m^3) digesters operating with a feedstock of 40 tonnes per day of cow, sheep and camel manure, grain residues and 1 tonne per day of slaughter-house waste. The plant was installed in 2011 with the aim of delivering 3 GWh of electricity annually (Karatayev and Clarke, 2015).

The country's first large solar power plant, "Stormy", opened in 2015 with a capacity of 50 MW. Total installed solar capacity, including small-scale solar, stands at 57 MW.

The geothermal field Kaplanbek (near the city of Shymkent) has a thermal water temperature of 80°C and supplies heat to residential buildings. Thermal water resources (temperature 80-120°C) near the city of Almaty are used for heating greenhouses in winter and for air-conditioning in summer (KazEnergy, 2015).

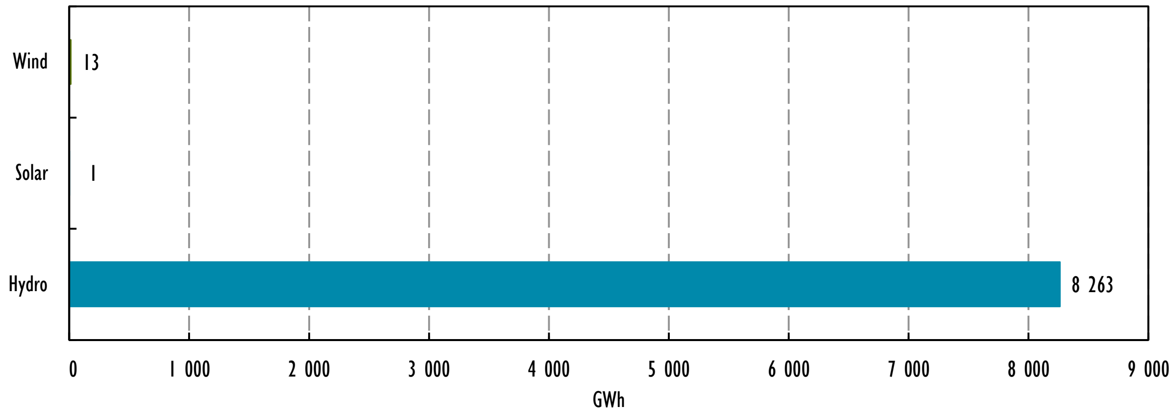
Figures 10 and 11 indicate the level of renewable energy in TPES and electricity generation.

Figure 10 • Energy production from renewables in Kazakhstan, 2014



Note: ktoe = thousand tonnes of oil-equivalent.
Source: IEA (forthcoming), *Energy Balances of Non-OECD Countries 2016*, www.iea.org/statistics.

Figure 11 • Electricity generation from renewables in Kazakhstan, 2014



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

2.2 Indicators and current levels of costs and remuneration

The IEA cost analysis shows that, given Kazakhstan's resource quality and availability, and the relatively high cost of financing, the least costly renewables to develop are geothermal, wind, utility-scale PV and landfill gas. Hydro, biomass, biogas (anaerobic digestion), municipal waste co-generation, and commercial and residential PV cost ranges are moderately higher, while municipal waste plants are the most costly investments.

In June 2014, the first feed-in tariffs for renewable power development were approved in Kazakhstan, at the following levels (which exclude value-added tax [VAT]) (Daviy, 2015):

- wind power: 22.68 KZT/kWh ≈ USD 0.07[20]
- solar power: 34.61 KZT/kWh ≈ USD 0.11
- small hydro: 16.71 KZT/kWh ≈ USD 0.05
- biogas plants: 32.23 KZT/kWh ≈ USD 0.1.

A special tariff of KZT 70/kWh (USD 0.38/kWh) was introduced for solar power stations using PV modules manufactured from Kazakh silicon, with a total cap of 37 MW capacity, in order to

[20] Applying the exchange rate of 327 KZT/USD as of 29 April 2016.

support domestic manufacturing. The tariffs were set to be valid for 15 years and are inflation-indexed to the consumer price index of Kazakhstan. A buyer model for generated electricity from renewables and a financial settlement centre were also established, as an affiliate company operating under the Kazakhstan Electricity Grid Operation Company (KEGOC).

When first introduced, the feed-in tariffs were considered to be much more advantageous for foreign investors than they are in 2016. This is mainly due to a significant depreciation of the KZT, which since 2015 has reduced by nearly half the value in USD of the feed-in tariff. In response, the government amended the rules on green tariffs in early 2016, allowing for annual indexing to the previous year's fixed tariffs in USD (East Time, 2016). The exact approach to this indexation will be included in a sub-law currently under development. A sub-law is also under developed to introduce a reserve fund for the payments of the feed-in tariffs to renewable energy project developers. The new policy and regulatory measures are hoped to have a positive effect on attracting foreign investment in renewable energy generation.

Step 3: Technology penetration and cost monitoring

3.1 Monitoring RET penetration over time

Under its Green Economy Concept, the Kazakh government plans at least 50% of its electricity generation to be met by fuels "alternative" to coal by 2050. It specifies that solar and wind would be the main renewable technologies to be developed over the next 25 years, aiming for 3% of electricity generation to be from wind and solar by 2020, and 10% by 2030.[21]

In order to achieve the 3% renewables target by 2020, the Action Plan to implement the concept between 2013 and 2020 projects that around 1 040 MW of additional renewables capacity will be necessary. In 2013, while developing the concept, the Kazakh government revealed plans for four solar plants with a total capacity of around 77 MW, 13 wind power plants with 793 MW capacity, and 14 hydropower plants with 170 MW capacity (PV Tech, 2013).

For large-scale technologies, this study adopts a "bottom-up" approach to monitoring deployment levels and assessing progress against national targets. Large-scale projects have been classified according to a four-tier rating system:

1. Announced: Where the intention to develop a site and initial scoping studies has 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.

Figure 12 shows that Kazakhstan has solar projects in the pipeline that go beyond its 77 MW capacity 2020 target. By 2016, around 55 MW of solar PV was already installed and an additional 250 MW of solar PV was either under construction or in planning in the Zhambyl province. There are no current plans to install CSP (Karatayev and Clarke, 2015).

At the start of 2016, it was announced that a further EUR 2 billion would be invested in three solar plants in the Shymkent, Turkestan and Kentau regions, although planned capacities are as yet unknown (Strategy2050.kz, 2016).

[21] Decree of the President of the Republic of Kazakhstan on 30 May 2013, Number 557.

Figure 12 • Projected large-scale solar energy capacity against national targets, Kazakhstan

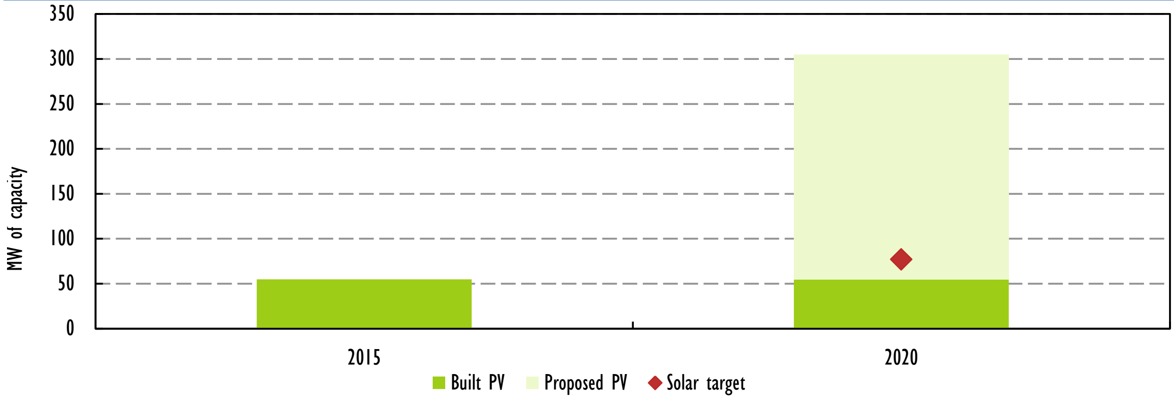


Figure 13 shows that the target for wind, 793 MW in 2020, is highly ambitious and that existing wind farms and those under construction are at present not nearly enough to reach the target.

Figure 13 • Projected wind energy capacity against national targets, Kazakhstan

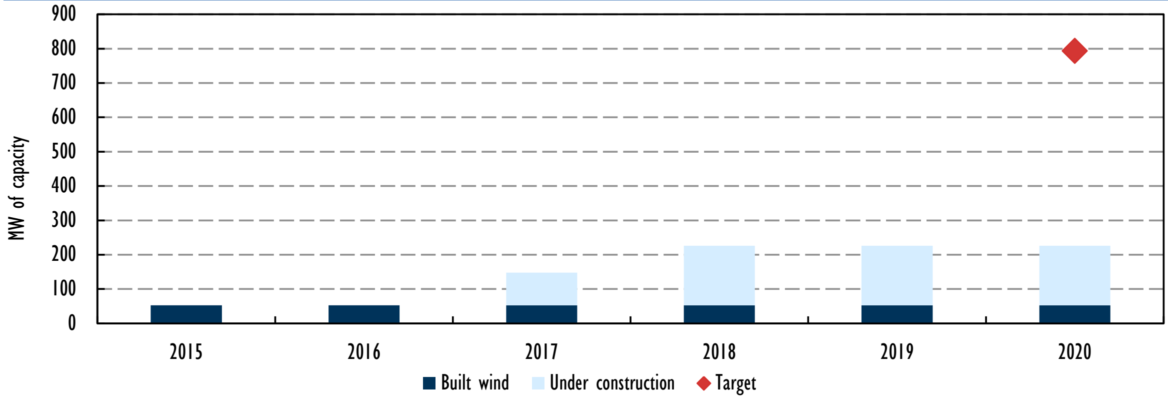
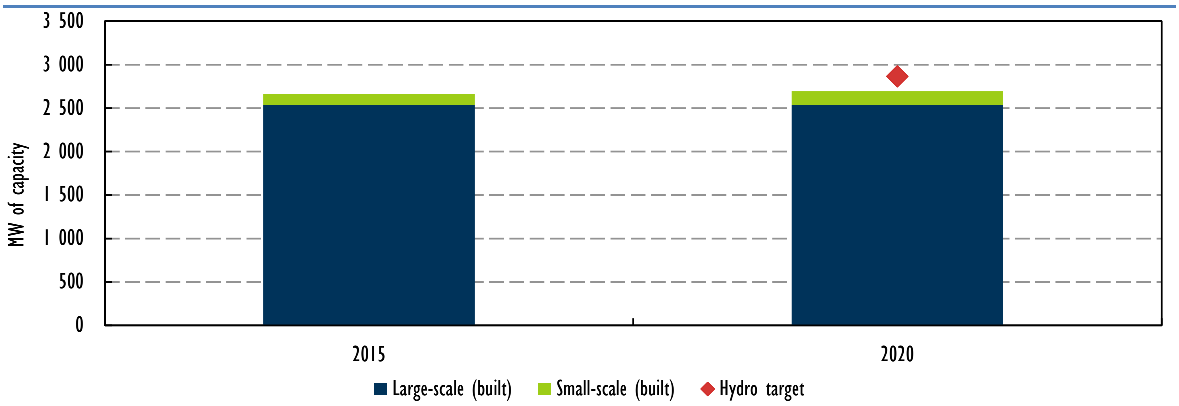


Figure 14 shows that existing installed large-scale and small-scale hydro is significant; however, the target calls for an additional 230 MW by 2020. At present, no hydro projects are under construction or proposed, which reduces the likelihood of Kazakhstan reaching its target.

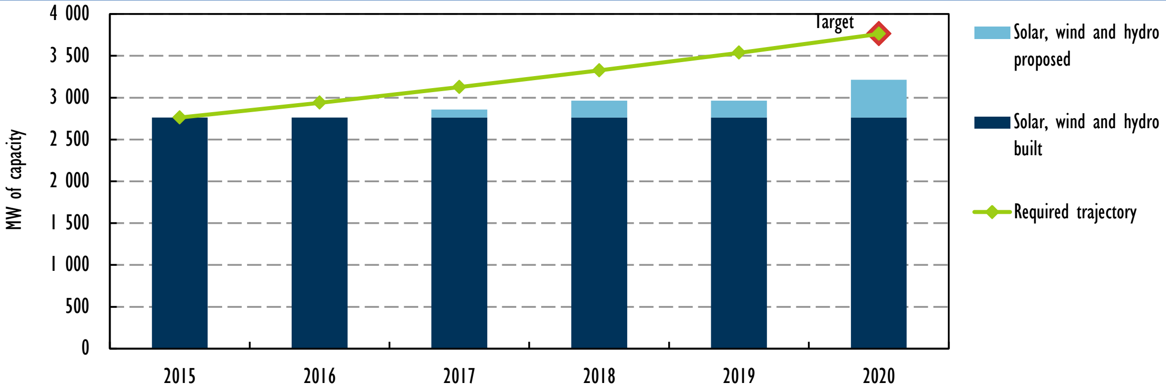
Figure 14 • Projected hydro energy capacity against national targets, Kazakhstan



IEA analysis shows that ambitious wind and solar programmes are necessary for Kazakhstan to reach its target of 3% of electricity generation to be provided by wind and solar by 2020, which requires an additional 1.8 GW of capacity. In order to succeed, these programmes also require targeted policies, favourable investment conditions, electricity market structure, and other enabling environment considerations. While a number of solar power development projects are in the pipeline, making the solar target of 77 MW by 2020 more likely to be reached, wind power development is lagging. Even if solar power development were to exceed the target over the next five years, significant wind power development would be required (Figure 15).

In addition to the above-mentioned projects, a new biogas plant began construction in January 2016 in the Kyzylzhar district of Northern Kazakhstan. The biogas plant is expected to use approximately 40 tonnes of raw materials per day to produce 9 500 m^3 of biogas per day (Strategy2050.kz, 2016).

Figure 15 • Current capacity and required trajectory to meet total solar, wind and hydro target, Kazakhstan



3.2 Monitoring and benchmarking the cost of RETs

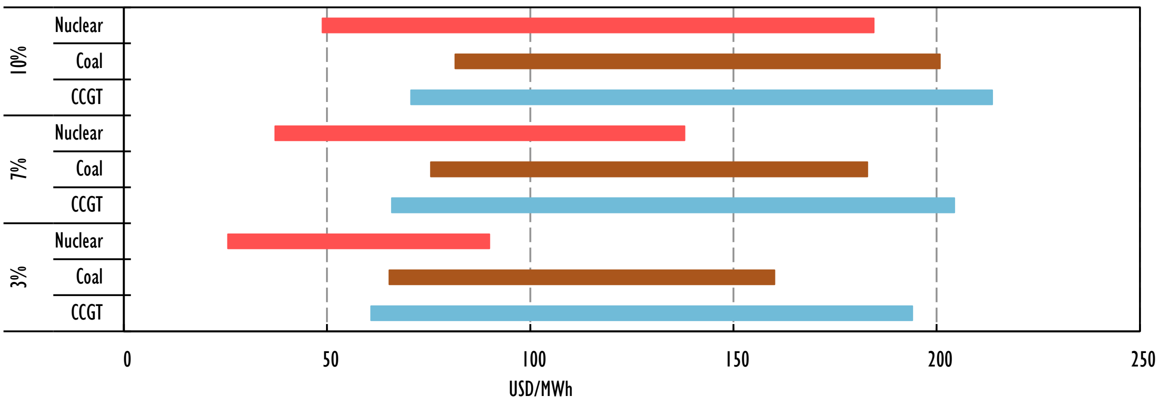
According to the IEA (2015b), investment in renewables globally has been driven by generous market incentives, along with the expansion of enabling policies to countries with good resources, technology improvements and favourable market conditions, which have helped spur investment to reduce the cost of production, leading to reductions in the average cost of renewables. Cost reductions have been most noticeable in solar PV and onshore wind, both in member countries of the 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 generous incentives, investment costs can remain inflated as equipment is priced accordingly, taking into account developers' return expectations.

Actual historical costs of renewables in Kazakhstan were not available for this study. It is recommended that the Kazakh government monitor costs over time and benchmark them against costs in countries with higher deployment levels, so that it can track the efficiency of its renewables development and competitiveness of its renewables market. The government should also track the market design and flexibility of other parts of its energy system, and try to benchmark these against other countries.

Kazakhstan should also benchmark the cost of renewables compared to the cost of other traditional baseload technologies, and track them over time. This is particularly true for coal, given the country's heavy reliance on coal for electricity and heat generation. Benchmarking renewables' costs against the cost of gas and nuclear power may also be of interest to Kazakhstan, given its consideration of developing both more gas-powered electricity plants as well as a new nuclear reactor. Other infrastructure investment needs, including the distribution network, also play a role in the economics of the projects. For example, upstream and infrastructure capital costs required for a gas fired power plant represent nearly two thirds of the total investment need, compared with only one quarter required for a coal-fired power plant.

Figure 16 indicates the global average cost range of gas, coal and nuclear power plants, at different discount rates. At the highest discount rate of 10%, which is the closest to the estimated discount rate in Kazakhstan, the cost ranges of gas and nuclear are similar to each other and to wind, geothermal and landfill gas, albeit lower than other RETs (Figure 5). The coal cost range is smaller albeit also similar to wind, geothermal and landfill gas. The existing feed-in tariffs are too low to make investments in renewable energy technology attractive to foreign investors.

Figure 16 • Range of levelised cost of electricity for baseload technologies (at discount rates 3%, 7% and 10%)



Note: CCGT = combined-cycle gas turbine.
Source: NEA/IEA/OECD (2015), *Projected Costs of Generating Electricity 2015*, OECD Publishing, Paris.

3.3 In-country monitoring systems

The government, in its Green Economy Concept, has three scenarios for power sector development:

- Base case scenario: "Business-as-usual" electricity demand, gasification of Astana and Karaganda regions, current low gas prices, 30% alternative share of generation in 2050.
- Green scenario – "expensive" gas: "Green" electricity demand, gasification of Astana and Karaganda regions, high gas prices, 50% alternative share of generation in 2050.
- Green scenario – "cheap" gas: "Green" electricity demand, gasification of Astana, Karaganda, Pavlodar and Eastern regions, low gas prices, 50% alternative share of generation in 2050.

According to the model used to estimate the outcomes of the three scenarios, key assumptions in all these scenarios include:

- electricity demand ranges from 136 TWh to 145 TWh in 2030 and from 172 TWh to 188 TWh in 2050
- greater availability of gas, corresponding to a lower price of gas for power generation
- maximum possible extension of a lifetime of existing coal, gas and hydro capacity
- installed capacity for renewable energy in 2030: 4.6 GW for wind and 0.5 GW for solar
- nuclear power plants are developed in accordance with national plans, such that total installed nuclear capacity will be 1.5 GW by 2030 and 2.0 GW by 2050
- co-generation in all major cities of gasified regions is converted from coal to gas in order to improve local air quality.

Given the country's measurable targets and different potential paths of development, the in-country monitoring system should track changes in the assumptions, as well as progress towards existing targets, under the different scenarios.

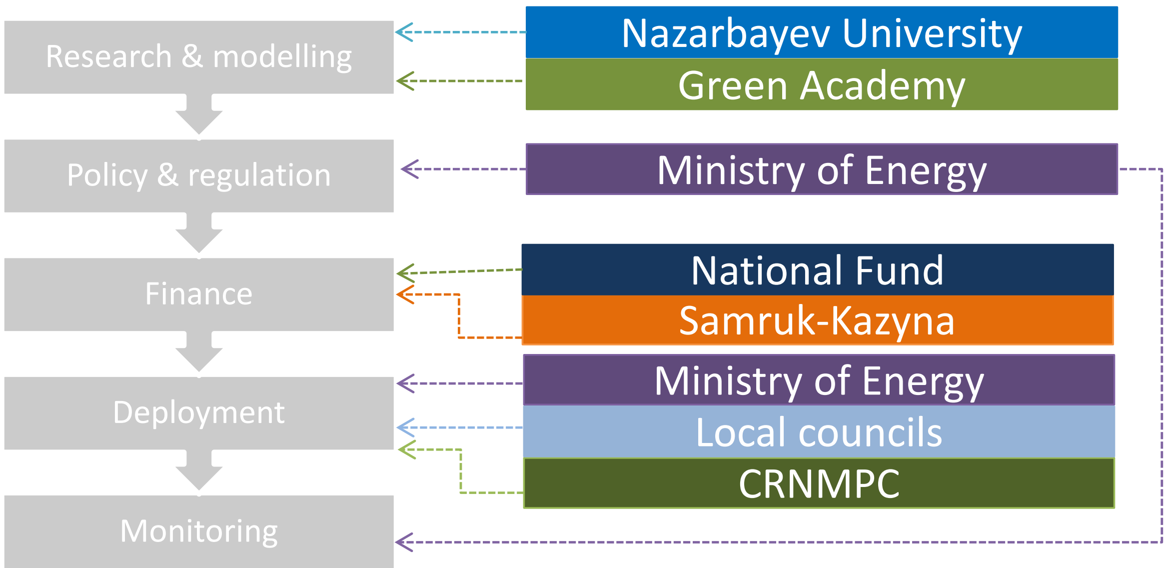
3.4 Enabling environment for priority technologies

Despite considerable renewable energy potential, the enabling environment for renewables development continues to be inhibited by the following barriers in Kazakhstan: low electricity tariffs; transmission losses and inefficient technologies; weak regulatory and legal frameworks; persistent governmental body reforms; inadequate levels and quality of scientific support; awareness and information barriers; and a high-risk business environment (Karatayev and Clarke, 2015).

Institutional and regulatory factors

Institutional framework

Figure 17 • Institutional framework for renewables development, Kazakhstan



The Ministry of Energy (Figure 18) was established in August 2014 as the lead ministry for energy policy and governance. The ministry was created following a merger of functions of the former Ministry of Oil and Gas, the Ministry of Industry and New Technologies, and the Ministry of Environmental Protection and Water Resources.

The Committee for Regulation of Natural Monopolies and Protection of Competition (CRNMPC), the regulator forming part of the Ministry of National Economy, is responsible for tariff setting and competition matters and its board is appointed by the prime minister. CRNMPC is financed from the state budget.

The Committee on Statistics at the Ministry of National Economy is responsible for statistics methodology, data gathering, processing and dissemination, and implementing relevant policy measures. The committee is responsible for developing the national energy balance in close co-operation with relevant ministries.

The Sovereign Wealth Fund Samruk-Kazyna is a state-run holding company for the management of Kazakhstan's state assets. Samruk-Kazyna was established by the merger of two joint-stock companies, Kazyna Sustainable Development Fund and Kazakhstan Holding for the Management of State Assets Samruk. The fund is a shareholder of almost all national development institutes and national companies. It incorporates all investment and innovative development institutions (the Bank for Development of Kazakhstan, the Investment Fund of Kazakhstan, the National Innovation Fund, the Damu Fund and KazInvest, among others). It also holds interests in the major banks (BTA Bank, Alliance Bank, Temirbank) and the national companies KazMunayGas, KEGOC, Samruk Energy, KOREM, KazAtomProm, the National Mining Company Tau-Ken Samruk, the National Company Kazakhstan Engineering, the Kazakh Research Institute of Energy (named after the academic Chokin) and others.

The National Fund is a state-run fund that comprises financial assets accumulated in Kazakhstan's government account with the National Bank of Kazakhstan. The National Fund accumulates the major part of oil revenues. The fund was one of the first to be established in the post-Soviet period. It was set up to work towards stable social and economic growth; financial resource accumulation for future generations; reduced exposure to adverse external impacts; and decreased exposure of the economy to volatile commodity prices.

KazEnergy is the energy industry association, grouping over 70 major players including resource extraction, power generation, and a range of energy-related services. Scientific research and capacity building in the sphere of the "green" economic growth is conducted by **the Green Academy** while economic and scientific research and modelling of different energy policy scenarios is done by **the Nazarbayev University.**

Policies and regulations

The Action Plan for the Development of Alternative and Renewable Energy for 2013-20 was adopted in January 2013. Under the plan, 31 renewable energy projects are proposed with a total capacity of 1 040 MW, including wind farms of 13-793 MW capacity, solar PV installations of 77 MW and 170 MW of hydropower plants. At the start of 2013, the country had 27 proposed renewable energy projects, including wind, solar, biogas and small hydro.

A key initiative in renewable energy is the Programme of Wind Power Development to 2030, which defines wind power development as a priority. The programme was prepared in conjunction with the UNDP Wind Power Market Development Initiative. The goal was to develop wind power to generate 900 GWh by 2015 and 5 TWh by 2024, however it is unclear how much capacity has been delivered under the project to date (as part of total wind development).

Small hydropower development programmes in Kazakhstan include reconstruction and renovation of previously constructed small hydro plants, adding small hydro to water-management projects with existing water-retaining structures with the aim of utilising waste releases, and construction of new small hydro for the supply of power to users in the outlying districts of the power system. Favourable factors for the development of hydro are:

- regional authorities' interest in small hydropower.
- provision of state short-term credits to private investors in small hydropower.
- provision of privileges (tax holidays) for the realisation of investment projects.

The government introduced a Law on Renewable Energy in 2012, which was followed by rules and regulations on: the purchase of electricity from qualified power-generating organisations; definition of the nearest point of connection to the grid or thermal network for renewable energy; monitoring of the use of renewable energy; and feasibility study assessments (Karatayev and Clarke, 2015).

However, according to Karatayev and Clarke (2015), while these rules provide procedures and details not covered in the Law on Renewables, the necessary regulatory and legal instruments, such as grid access and construction permits, have yet to be legislated and regulated, and as such are the main instruments missing in the development of RETs.

Most recently, in June 2016, the government announced plans to develop an energy auction system for renewable, in order to increase transparency and effectiveness of the market (The Astana Times, 2016). The decision on the auctions was developed in consultation with numerous international organisations and governments.

Technical and infrastructure factors

In the electricity sector, third-party access to the transmission and distribution networks is allowed based on licensing and safety requirements. Generation, transmission and distribution activities require licences from the relevant ministry or the CRNMPC. KazEnergy indicated in its National Energy Report 2014, carried out on behalf of the government, that the following major technical limitations to large-scale deployment of renewable energy: frequency and capacity balancing, voltage fluctuations, vibration frequency disruptions and volatility of supply, among others (Karatayev and Clarke, 2015). The report shows that the electricity grid is not equipped to incorporate large-scale integration of renewables at present, and that significant investments in the network infrastructure are required in order not to reduce reliability when integrating variable renewable energy sources.

The electricity transmission and distribution networks across the country are already inefficient, with losses estimated at approximately 15%. Efficiency of incorporating new renewable energy sources will also depend on geographical distances from the point of generation to the point of consumption, potentially leading to high transmission and distribution losses if the energy source is not physically close to its consumers, which can often be the case in countries with dispersed population centres like in Kazakhstan (Karatayev and Clarke, 2015).

Financial and market factors

To address slow investment in energy infrastructure during times of growing demand, the government introduced an interim tariff structure in 2009 that allows all electricity generators to charge a premium to be used to modernise their assets. The tariff expired in 2015.

In July 2014, the government approved the green tariff for four types of renewable energy sources (excluding VAT), based on the Law on Supporting the Use of Renewable Energy Sources (see earlier section). However, since its introduction in 2014, the value in USD of the feed-in tariffs has fallen by half due to a significant devaluation of the KZT, to levels that are below the estimated renewables generation costs. As such, the government is currently developing legislation to index the tariff to USD, which would remove the risk of currency fluctuations and provide a more predictable environment for foreign investments.

Capital investment requirements and the availability of finance are a key limitation to renewables development in Kazakhstan. The availability of finance is limited, a concern that is echoed around the world, and its cost is moderately high. Foreign financing is also exposed to exchange rate fluctuations; the KZT to USD exchange rate doubled during 2015, which has a significant effect on the cost of borrowing in foreign currencies. Similarly, the exchange rate with the Russian rouble has exhibited strong volatility, falling by nearly half during 2014 and then rising back to its average levels by mid-2016.

The following financial incentives are available to foreign investors for what are classified as "priority projects" by the government (aligning with the government's overall priorities, including alternative energy development), or for projects within Special Economic Zones:

- exemption from corporate income tax (20 %) for up to 10 years

- exemption from land tax for up to 10 years
- exemption from property tax for up to 8 years from the date when fixed assets (e.g. a plant) are commissioned (only for those assets which were commissioned for the first time)
- reimbursement of up to 30% of actual expenses on construction works and purchase of equipment, where a feasibility study has been approved by the state
- exemption from the need to obtain work permits for foreign workers of the legal entity holding the investment contract, its contractors and subcontractors in the area of research and design activities, engineering services and construction works
- "one-stop shop" administrative procedures
- simplified procedure for obtaining land plots for a project
- exemption from customs fees for the import of technological equipment and spare parts, for the period of an investment contract, but not more than five years.

The incentives are implemented once an investment contract is signed with the Investments Committee of the Ministry of Industry and New Technologies (Embassy of the Republic of Kazakhstan to the United States, 2016).

Tariff subsidies

Household retail energy prices in Kazakhstan are among the lowest in the world due to government subsidies and regulated retail tariffs that are not cost-reflective. As such, consumers are unaware of the true cost of energy and are not incentivised to save or gain an understanding of the true cost of energy. According to the OECD (2014a), in 2011 in Kazakhstan the average fossil fuel subsidy was about 33%, expressed as a proportion of the full cost of supply. The estimated total fossil fuel subsidies in 2011 were USD 5.85 billion, which represented about 3.3% of the country's GDP in that year. Most of the subsidies went to oil and petroleum products (about 55%), followed by electricity (about 30%) and coal (about 10%).

In order to further incentivise renewables development in Kazakhstan, the government should progressively phase out energy subsidies, while making sure that the most vulnerable customers are properly looked after. Once implemented, the phase-out of subsidies would allow the government to reduce funding towards inefficient use of energy, increase transparency over the true cost of energy production and allow funding for more targeted investment.

Social factors

Public awareness of renewables in Kazakhstan is relatively low, as the country is rich in affordable fossil fuels. The general public's perception is that renewables are more costly and difficult to integrate into the existing network, and that their development would lead to higher prices and problems in the grid. As such, a strong public campaign is needed to inform the public of the true cost and benefits of renewables.

Development of renewables also requires investment in human resources and staff training. According to the Samruk-Energy Annual Report (2015), the largest energy consortium in Kazakhstan, lack of qualified staff is one of the company's key operating risks. To tackle this issue, the company has a number of training schemes within its subsidiaries, providing training to thousands of employees per year.

Nazarbayev University is the most influential provider of higher education in the country, with close ties to the Kazakh government. Energy is one of the key focuses of the university's education and research activities. In October 2010, the university launched the Centre for Energy Research, renamed the Nazarbayev University Research and Innovation System Centre in 2012, which focuses on R&D in energy. Additionally, the university offers courses on energy engineering and management, designed in line with to the latest best practice and international standards.

Environmental factors

Kazakhstan's environment has been affected by past military nuclear testing programmes and industrial and mining activities, as well as land degradation, desertification and water scarcity. A number of these problems affect the entire Central Asia region. In response, Kazakhstan pioneered a multilateral, cross-sectoral and voluntary Green Bridge Partnership Programme. The programme addresses issues related to energy and water linkages in Central Asia. Kazakhstan's dependency on transboundary river inflows, inefficient irrigation systems for water-intensive crops and a decrease in sustainable water supply are mounting concerns. Water deficits of 14 billion cubic metres (bcm) by 2030 and 20 bcm by 2050 are expected in the Central Asia region, with serious impacts on the Balkhash-Alakol and Aral-Syrdarya basins.

To streamline water and energy governance, in 2013 the Ministry of Environmental Protection was reorganised into the Ministry of Environment and Water Resources, and in 2014 the reorganised ministry merged with the newly created Ministry of Energy. The government approved a comprehensive Water Management Programme in December 2013, with concrete measures and mechanisms to implement a sustainable water use strategy. Water management is tied to energy management through the nexus between the water needs of energy production and the energy needs of water treatment. Water shortages directly affect hydropower generation and the generation of energy using water for cooling (such as coal-powered generation), and as water restrictions rise, the most environmentally feasible technologies are likely to be the least water-intensive renewables (wind and solar).

Kazakhstan ratified the Kyoto Protocol in 2009 and for COP21 it committing to reduce GHG emissions by 15% below 1990 levels by 2030. This translates into emissions increases compared to 2012 levels of 13% and 1% in 2025 and 2030 respectively (Climate Action Tracker, 2016). Kazakhstan will host Expo 2017 "Future Energy" that aims to showcase the latest energy technologies and to raise awareness of sustainable development.

Lessons learned from the pilot study

Data quality review

The main sources of information for the RET analysis for Kazakhstan have been data from annual energy balances modelled by Nazarbayev University. The IEA collects annual balances from Kazakhstan; however, as the Nazarbayev University has provided a more detailed analysis of estimated sector end-use for the energy efficiency section of the report, for the purposes of consistency throughout the report, the renewables section also reflects estimates from the same database. It has been noted that Kazakhstan's energy balance data submitted to the IEA is incomplete and inconsistent with the Nazarabayev University estimates. The IEA is continuously working with the government of Kazakhstan to improve data collection and quality.

Some data were sourced through secondary research, with the sources referenced throughout the report. The majority of the information gathered on policy developments has been gained through secondary research. Data are currently lacking on the actual costs of RETs, and therefore estimated cost ranges have been used.

Recommendations for future users of the methodology in Kazakhstan

Given that the Ministry of Energy is the lead body on energy policy development and for implementing RETs in Kazakhstan, it is the logical ministry to use the methodology in the future. In order to monitor future RET developments, the ministry would be required to develop methods and systems to complete the data on RET penetration, including the level of current RET capacity, which is incomplete at present. The ministry would then be best placed to develop a clear and transparent RET monitoring system, measuring current levels of penetration against medium- and long-term targets.

Results of the pilot study for EETs

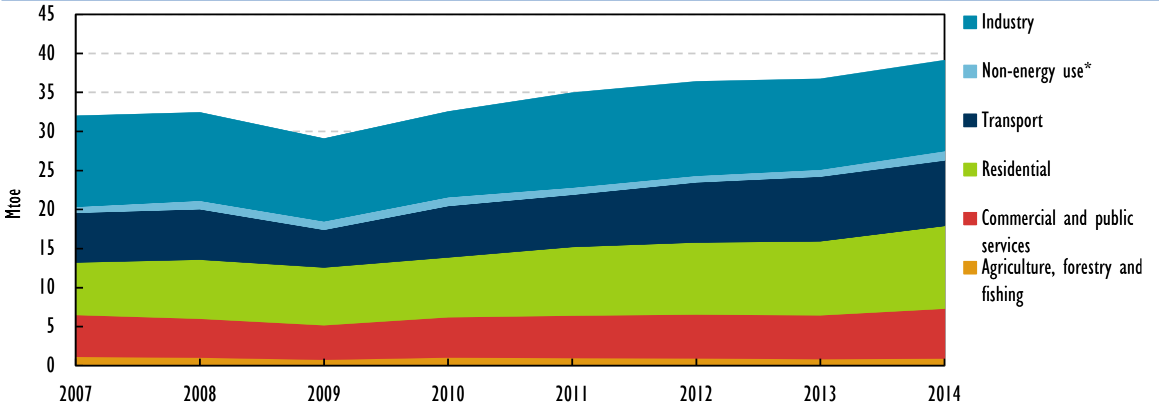
Step 1: Prioritisation

1.1 National energy end-use data analysis

According to Nazarbayev University's total final consumption (TFC) statistics for Kazakhstan, industry and the residential sector are the largest energy-consuming sectors. The industrial sector represents 29.5% of TFC, while the residential sector and transport account for a further 27.1% and 21.5%, respectively. The commercial and public services sector is also a significant energy consumer at 16.3% of demand, with the remaining TFC in the agriculture, forestry and fishing sector (2.5%) and for non-energy use (3.1%) (Figure 18).

Figure 18 shows that over the seven years to 2014, TFC has been growing in nearly all sectors, with a dip during the economic downturn of 2008-09. From 2007 to 2014, TFC growth was the strongest in the residential sector, increasing by 57.6%. Transport demand was 32% higher. Commercial and public services energy use increased by 19.1%, while agricultural use contracted by 18.6%. Industry TFC was 0.1% lower in 2014 compared to 2007, exhibiting an overall stagnant effect albeit with some volatility: demand contracted by 6.3% in 2009, with a 14.4% recovery in the two years after, followed by a contraction in the three years to 2014.

Figure 18 • TFC by sector, Kazakhstan, 2007-14



* = Non-energy use constitutes fuels used as raw materials.

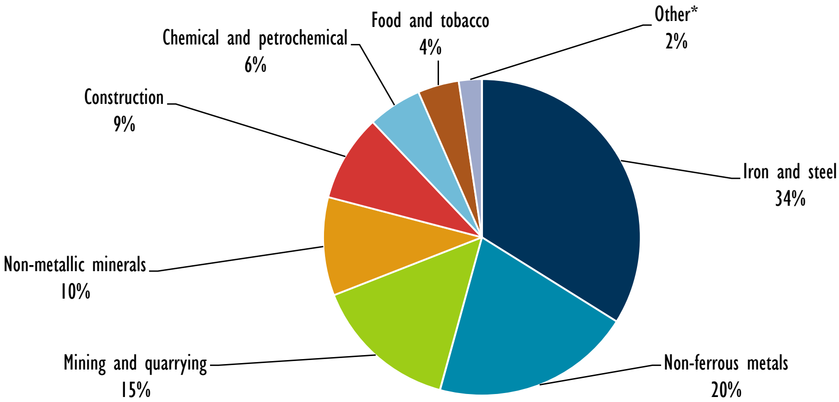
Source: Nazarbayev University (2016), "Kazakhstan energy balances for 2007-14", submission to the IEA.

The following analysis focuses on a breakdown of energy consumption in the four largest consuming sectors.

1.1.1 Industrial sector end-use

Figure 19 shows total final energy consumption by the largest industries.

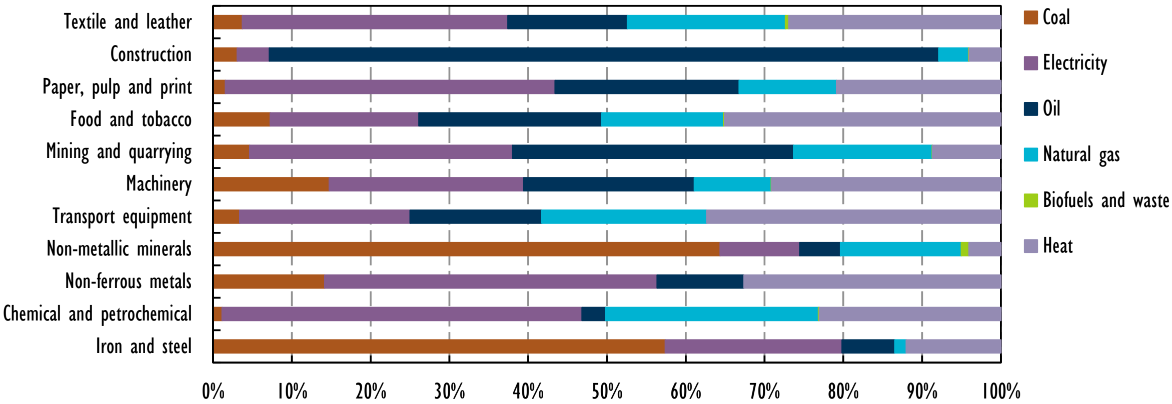
Figure 19 • Industry TFC by type of industry, Kazakhstan, 2014



* = Other includes machinery, textiles and leather, transport equipment, paper, pulp and print and non-specified.
Source: Nazarbayev University (2016), "Kazakhstan energy balances for 2007-14", submission to the IEA.

In the industrial sector, the largest energy-consuming subsectors are the iron and steel sector (34%) and non-ferrous metals industry (20%) (Figure 19). The main products in the iron and steel industry include crude steel, cast iron, ferroalloy and ferrochrome. The mining and quarrying and non-metallic minerals subsectors account for 15% and 10%, respectively, while the remainder is made up of construction (9%), chemical and petrochemical industry (6%), food and tobacco (2%) and machinery (2%) subsectors.

Figure 20 • Industry TFC by fuel type, Kazakhstan, 2014



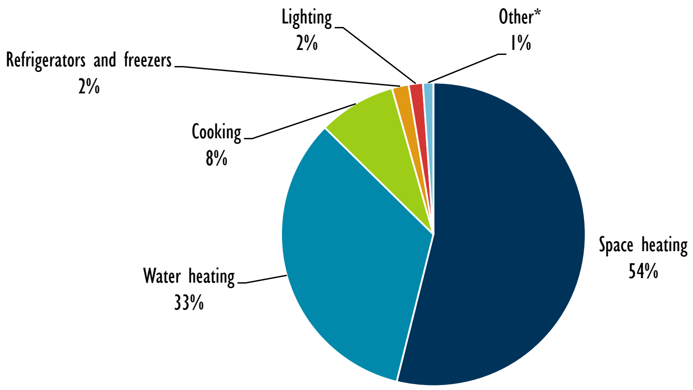
Source: Nazarbayev University (2016), "Kazakhstan Energy Balances for 2007-14", submission to the IEA.

As Figure 20 shows, in 2014 coal was the main source of energy in iron and steel and non-metallic minerals (more than 50%), while oil products were the main fuel in construction and mining and quarrying. Electricity represents a large share of final energy use in non-ferrous metals, chemical and petrochemical, and paper, pulp and print (around 40-60%). Manufacturing industries, transport equipment, machinery and food and tobacco use heat as the main source of energy (other than heat generated in processes on-site).

1.1.2 Residential sector end use

Figure 21 shows residential energy consumption for Kazakhstan. Unsurprisingly, given the climate, space heating and water heating are the two largest end-uses, at 54% and 33% respectively. Cooking is the third-largest energy-consuming end-use in the country with an 8% share.

Figure 21 • Residential sector energy consumption breakdown, Kazakhstan, 2014

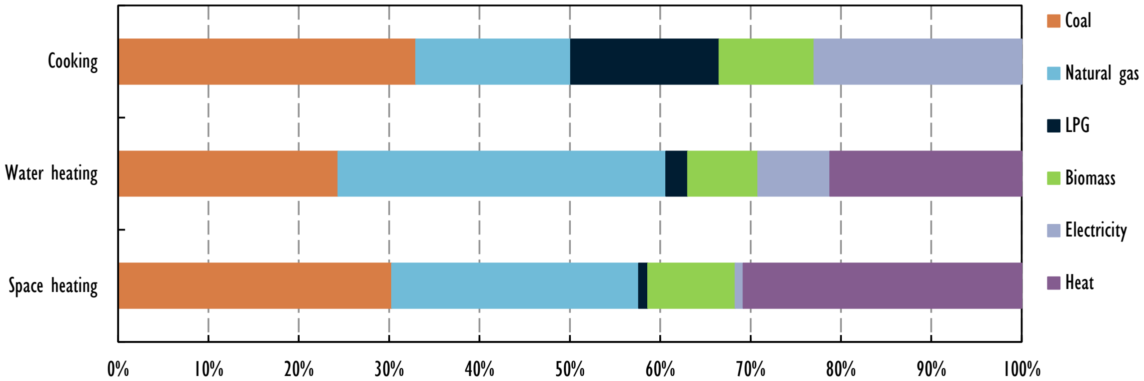


* = Other includes clothes washing and drying, dishwashers and other non-specified.

Source: Nazarbayev University (2016), "Kazakhstan energy balances for 2007-14", submission to the IEA.

Space heating and water heating in Kazakhstan's residential sector are mainly fuelled by natural gas and coal, or through heat obtained from district heating. Biomass also plays a significant role through the use of charcoal and wood, while electricity is used in around 10% of water heating and less than 5% of space heating (Figure 22).

Figure 22 • Residential cooking, water-heating and space-heating energy consumption by fuel, Kazakhstan, 2014



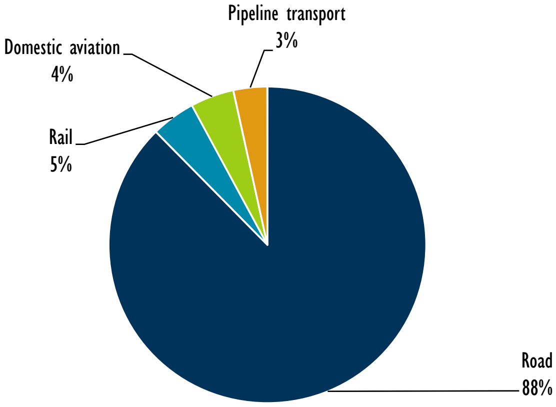
Note: LPG = liquefied petroleum gas.

Source: Nazarbayev University (2016), "Kazakhstan energy balances for 2007-14", submission to the IEA.

1.1.3 Transport sector end use

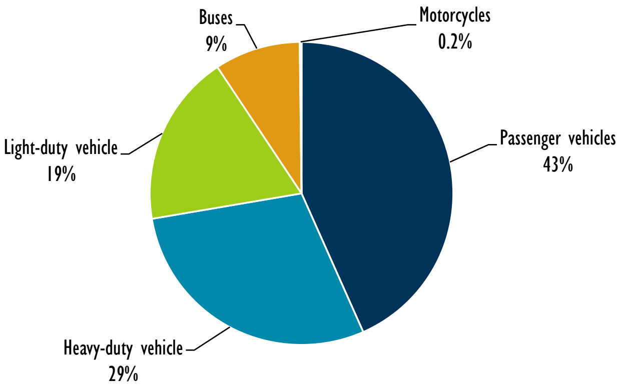
The breakdown of transport energy consumption by mode is shown in Figures 23 and 24. Road transport represents 88% of energy consumed, rail around 5%, while domestic aviation and pipeline transport account for 4% and 3%, respectively.

Figure 23 • Transport TFC by mode, Kazakhstan, 2014



Source: Nazarbayev University (2016), "Kazakhstan energy balances for 2007-14", submission to the IEA.

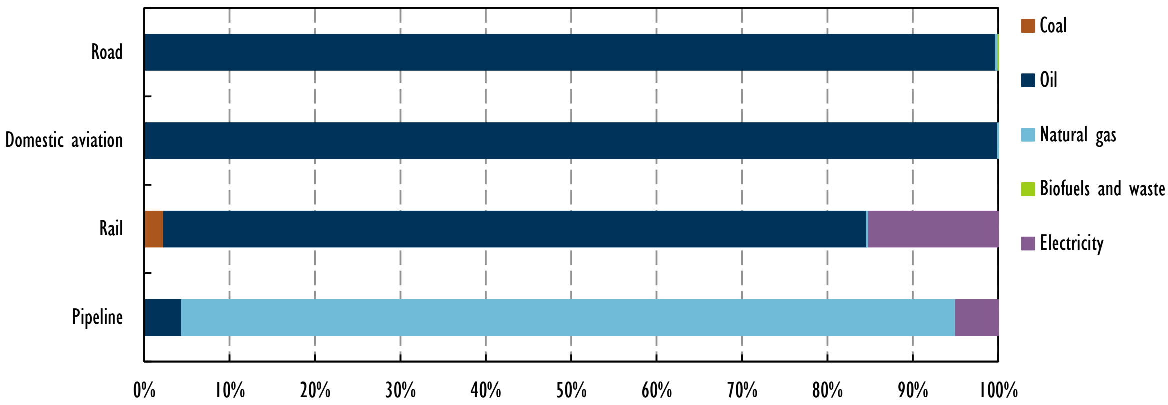
Figure 24 • Road transport energy consumption, Kazakhstan, 2014



Source: Nazarbayev University (2016), "Kazakhstan energy balances for 2007-14", submission to the IEA.

Figure 25 shows the breakdown of different modes of transport and what fuels they rely on.

Figure 25 • Transport TFC by mode and by fuel, Kazakhstan, 2014

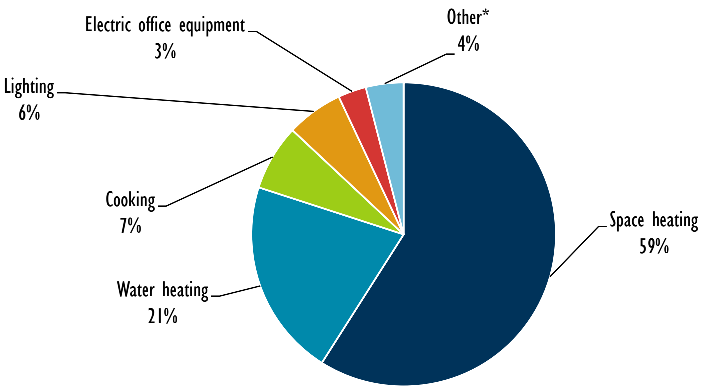


Source: Nazarbayev University (2016), "Kazakhstan energy balances for 2007-14", submission to the IEA.

1.1.4 Commercial sector

Space heating and water heating are the largest consuming end-uses in the commercial and public services sector in Kazakhstan, with shares of 59% and 21%, respectively. Cooking (7%) and lighting (6%) are also significant, with the remainder accounting for 7% (Figure 26).

Figure 26 • Commercial and public services sector end-use, Kazakhstan, 2014



* = Other includes refrigeration and non-specified.

Source: Nazarbayev University (2016), "Kazakhstan energy balances for 2007-14", submission to the IEA.

Reliable data on the fuel mix of commercial sector end-uses were not available for this study.

1.2 Trends in energy use, drivers and policies

This section summarises a selection of the key trends, drivers and policies that may affect future energy consumption in each of the major end-use sectors. It reflects expert judgement on the major drivers that could influence future energy use in each sector, as opposed to being an exhaustive study.

Future energy consumption in each sector in Kazakhstan has been modelled by Nazarbayev University experts (Kerimray et al., 2015; Suleimenov et al., 2016), using the TIMES modelling framework, with economic development growth input provided from the Computable General Equilibrium Model (CGE) developed by DIW Econ (2014).

The TIMES model generator is a tool to fully represent the energy system as a technology-specific economic environment and to assess various scenarios in reducing consumption and CO_2 emissions. The model is based on the national energy balances for 2011 (Kerimray et al., 2015) and detailed data on the power sector (including data for the full chain from indigenous production to end-user consumption). Energy data are updated on a regular basis and used for modelling various projection scenarios. Demand projections in terms of real output for industry sectors, agriculture, commercial and air transport sectors were obtained from the CGE model for Kazakhstan developed by DIW Econ (2014). Residential and transport sector demand projections were obtained through drivers (GDP and population) and corresponding elasticities.

1.2.1 Overall drivers

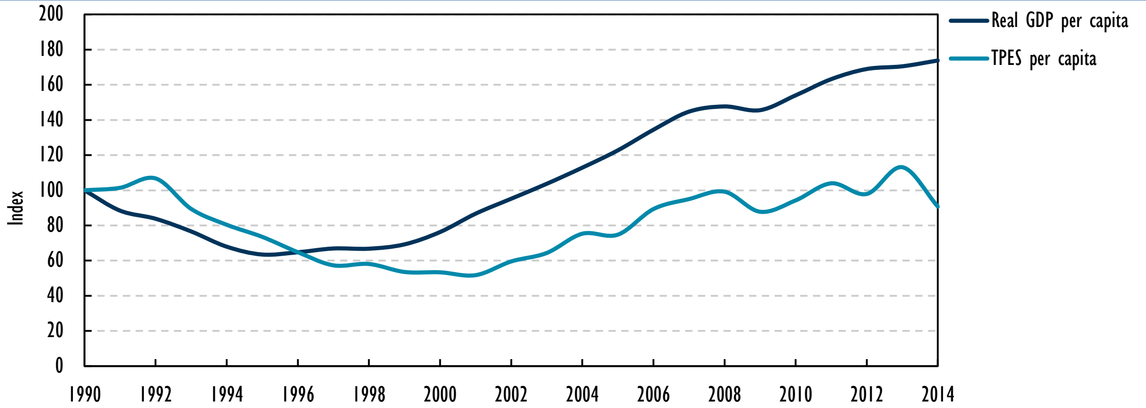
Economic growth

Kazakhstan's real GDP (measured in 2010 USD prices with PPP) grew at an annualised rate of 7.5% from 2000 to 2014, while real GDP per capita increased at 6.4% per annum (Kazakhstan's population was 16% higher in 2014 compared to 2000). Economic growth was mainly driven by upstream oil exploration and development, with oil production increasing at 6.2% per annum over the same period.

Kazakhstan's TPES per capita grew at 4.5% per annum from 2000 to 2014. Despite a significant increase in oil production, Kazakhstan's domestic demand (TPES per capita) was slower due to a structural change in the economy, leading to higher oil exports. Nazarbayev University's modelling of the energy balances shows that commercial sector energy consumption grew by a factor of 3.64 during 2000-14, transport sector demand grew by a factor of 3.27 over the same period, and residential sector demand expanded by a factor of 2.6. Conversely, industry energy consumption grew by a factor of just 1.63 over the 14 years, indicating a move toward less energy-intensive sectors, such as services, transport and households. The structural change has also partially occurred due to an economic downturn during 2008-09, which resulted in a decline in industrial activity.

Figure 27 demonstrates the similarity between rates of growth in GDP per capita and TPES per capita before 2008, and the partial decoupling since. Kazakhstan's energy intensity, measured as real GDP over TPES, was 16.5% lower in 2014 compared to 2008.

Figure 27 • Real GDP per capita and TPES per capita, Kazakhstan, 1990-2014



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

According to Nazarbayev University modelling, GDP is expected to grow by 83% by 2030 compared to 2011, with residential sector energy consumption growing by 11%, transport sector by 159%, industry by 56% and the commercial sector by 116%. This is a significant slowdown compared to the 20 years prior, largely due to a decline in the price of oil in 2015 and an uncertain outlook in the medium- to long-term. Growth in energy consumption is also expected to be slower compared to the two decades prior to 2011 through continuing structural changes in the economy.

Population and urbanisation

Urbanisation and population density are key drivers of change in energy consumption patterns. Urbanisation can lead to a decrease in residential energy consumption on the basis of energy use per dwelling, because building floor space for urban dwellers tends to be smaller than that for rural dwellers, meaning lower space heating and cooling requirements. However, this can sometimes be offset by the greater variety of energy end-uses available to urban dwellers than rural dwellers. Urbanisation and population density, particularly in urban areas, can also affect transport energy use. As population density increases, particularly in urban areas, the necessity and economic viability of public transport systems increases, which can enable a shift toward more energy-efficient forms of transport compared to private vehicles.

Kazakhstan's population grew at 1.1% per annum during 2000-14, increasing from 14.9 million in 2000 to 17.4 million in 2014. According to the country's census in 2009, around 54% of the population was living in urban areas, a share that has increased slightly to 55% in 2014. According to the United Nations (UN) (2016) *World Urbanization Prospects* database, urbanisation in Kazakhstan will continue to grow, reaching a 65% share of population by 2050. The UN (2016) also estimates a 26% increase in the Kazakh population from 2011 to 2030.

National energy efficiency policies and targets

In 2013 the Kazakh government approved the Energy Efficiency 2020 Programme, with an objective to reduce energy consumption by 10% every year until 2015[22] and to decrease energy intensity of GDP by 40% in 2020 (compared to 2008). Overarching areas of improvement include:

- modernisation and improvement of energy efficiency in the industrial sector
- reduction in the level of losses in electricity and heating
- large-scale promotion of energy savings among the population
- development and implementation mechanisms that encourage energy conservation and energy efficiency
- development of mechanisms for energy service companies (ESCOs)
- training in the field of energy saving and energy efficiency
- reducing fuel consumption in the transport sector
- a decrease in the production of 1 kWh of electricity and 1 gigacalorie of heat per square metre (m^2) in the housing sector.

The programme has nine areas of improvement, including energy efficiency measures in the industrial, residential and commercial sectors, transport and lighting (among others that cover power generation, construction and public awareness). 2020 targets for these sectors are:

- industry: energy efficiency improvements in industry as a whole of 30%; 20% in the mining and metals industry; 32% in the chemical industry; and 40% in the machine-building industry
- residential and commercial: energy consumption reduction of 20%
- transport: reduction in fuel consumption by road, rail and air transport of 30%; public fleet renewal up to 50%
- lighting: reduction in expenditure on electricity of up to 60%; 100% use of energy-efficient lamps (e.g. light-emitting diode [LED] and fluorescent lamps).

Financial incentives

At the time of approval, the Energy Efficiency 2020 Programme was estimated to cost around KZT 1.18 trillion (USD 3.6 billion as of May 2016), with KZT 145.6 million from the national budget, KZT 4.9 billion from local budgets and KZT 1.17 trillion from public enterprise budgets.

No specific fund is dedicated to the implementation of energy efficiency measures in Kazakhstan. The Energy Efficiency 2020 Programme envisages that residential and public spaces investment would be conducted through the existing Housing and Community Services Development Fund, which is currently targeted at assisting households and municipal governments in attaining credit and leases, attracting private investment, aiding unprofitable companies, and conducting financial monitoring of investment projects. The fund was created in 2012; however, information on the level of investment conducted by the fund or their activities in energy efficiency are not available at present (Kerimray et al., 2016).

Energy service companies (ESCOs) are not widespread in Kazakhstan at present and awareness of the concept and its 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 the bundling

[22] According the energy balances provided by the Nazarbayev University, total energy demand measured by TPES increased by 5.5% from 2013 to 2014, while total final consumption grew by 6.5% over the same period.

of projects, and provide other operational improvements in energy efficiency measures. However, ESCO market development can be challenging in countries with predominantly state-owned industries, due to centralised financial management and lack of commercial incentives. A strong foreign investment climate is necessary for a rapid uptake of ESCO services.

Fuel prices and subsidies

In general, fuel prices, including those for oil, gas and coal, influence demand in times of fluctuation, with lower prices increasing demand for the said fuels while reducing the incentive for investment in energy efficiency measures. However, at times of lower fuel prices, policy makers have a greater incentive to ease subsidies in retail pricing for those fuels, without having a significant impact on vulnerable consumers.

The OECD (2014a) estimated that total fossil fuel subsidies in Kazakhstan represented around 3.3% of the country's GDP in 2011, stating that "the subsidies were distributed among oil and petroleum products (about 55%), electricity (about 30%) and coal (about 10%)". Due to subsidies, retail prices for oil products are around half the export price. Electricity and heat tariffs are officially set at the cost recovery level, although the cost of capital expenditure is excluded from the calculations, keeping prices lower and reducing funds for capital investment.

Compared with most Central and Eastern European countries, heat tariffs for district heating in Kazakhstan are low. In 2009, the government established a scheme to guarantee tariffs for heat distribution companies in order to encourage investment in the modernisation of district heating networks (OECD, 2014a). No details of the results of this pricing scheme were available for this study.

Cost-reflective tariffs and the phase-out of subsidies are among the most effective ways to incentivise reductions in unnecessary energy waste and curb demand growth. Until the subsidy of all energy sources is reduced or eventually phased out, it is likely that Kazakhstan will continue to experience energy wastage. That said, the phase-out of subsidies would have to be managed carefully to avoid adverse impacts on sections of the population whose livelihoods depend on subsidised fuel.

At present, there are no clear government plans to phase out energy subsidies.

1.2.1 The industrial sector

Projected industry trends

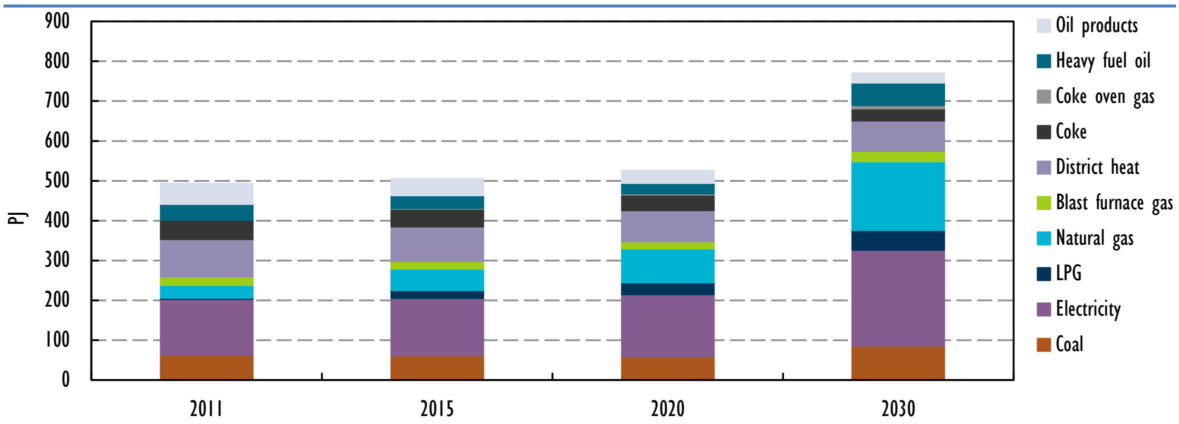
The results of Nazarbayev University's TIMES modelling suggest that industrial energy demand to 2020 is not expected to rise significantly as compared to 2011, increasing by 7%. This is based on industry growth figures obtained from the CGE model for Kazakhstan (DIW Econ, 2014), which was calibrated to recent IMF forecasts for Kazakhstan.

Energy-intensive industries, including iron and steel, aluminium, copper and other non-ferrous metals, are projected to maintain steady production to 2020, but growth is expected to pick up from 2020. Metallurgy is projected to be the slowest-growing sector compared to other industry subsectors (in terms of energy demand), with demand increasing by 53% by 2030 (on 2011 levels). In contrast, energy demand from the machinery industry and the minerals industry is projected to grow by a factor of 3.3 and 2.3 respectively over the same period.

The Nazarbayev University TIMES model "business-as-usual" (BAU) scenario assumes that up to 2020 no significant fuel switching or technological improvements take place in the industrial sector. However, by 2030 a significant reduction in energy intensity and improvements in technology may appear in ammonia production, aluminium production (inert anodes and recycled production), paper production (recycled pulp production), copper production and iron and steel production (electric arc furnaces). The reduction in industry energy intensity, even in the BAU scenario, demonstrates the large potential for energy saving in this sector.

Energy consumption in the industrial sector under the BAU scenario rises by 56% by 2030 compared to the year 2011, with the highest increase between 2020 and 2030 (driven by increased economic growth). With regard to fuel use, the BAU scenario suggests a significant increase in natural gas use in the industrial sector, with its share increasing from 6% in 2011 to 22% in 2030, while electricity consumption increases by 71% from 2011 to 2030 (Figure 28).

Figure 28 • Estimated industrial energy consumption in the BAU scenario, Kazakhstan, 2011-30



Source: TIMES model BAU scenario results, Suleimenov B. et al. (2016), “Exploring pathways for fulfilment of Kazakhstan's INDC targets”, presentation, International Energy Workshop 2016, 1-3 June, Cork, Ireland.

Industry structure

The degree of industrial 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 play 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.

In the case of Kazakhstan, the two largest consuming industries, iron and steel and non-ferrous metals, are relatively highly concentrated, with a total of eight facilities in iron and steel and six in non-ferrous metals. Production processes for particular industry products, and therefore the use of specific technologies, are even more concentrated into one or two facilities, as each facility specialises in the production of only a number of industry products (KazCham, 2015). The age of those facilities, however, is not clear for the purposes of this report.

Industrial policy

The Kazakh government has an ongoing programme aimed at the innovative development of the industrial sector, increasing output and exports as well as minimising cost and energy consumption.

The State Programme for the Industrial Innovation Development of Kazakhstan for 2015-19 (replacing the previous five-year programme) sets the following indicators to be met by 2019, compared to 2012 levels:

- growth in the volume of manufacturing industry output of 43% in real terms
- growth in gross value-added in the manufacturing sector of not less than 1.4 times in real terms
- growth in labour productivity in the manufacturing industry of 1.4 times in real terms
- growth in the value of non-primary (processed) exports of not less than 1.1 times
- reduction in manufacturing energy consumption of at least 15%.

Within its Energy Efficiency 2020 Programme, the government has reaffirmed not only the need to create favourable macroeconomic conditions for the development of the industrial sector, but also the need for a large technological upgrade and a national innovation development system, as well as investment in human capital. Steel production is one of the major priorities for modernisation, with the focus on increasing the production of a number of steel products.

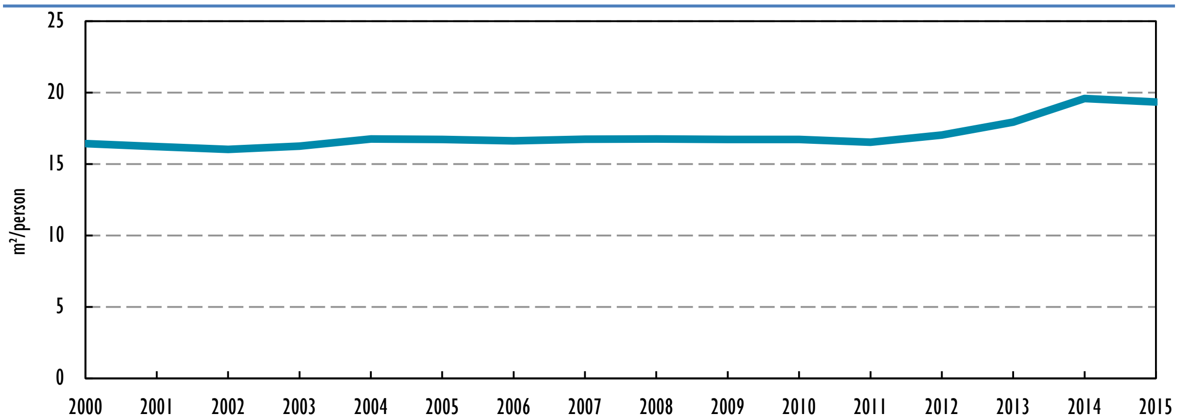
According to the OECD (2014b), "steelmakers in the Commonwealth of Independent States (CIS) are replacing outdated open-hearth furnaces with new basic oxygen and electric arc furnaces, and investing in energy-saving technologies as well as steel-making and rolling operations. Steelmaking capacity in the entire CIS region was estimated to increase by 7.1% between 2011 and 2014 (10.3 Mt)". The most significant current plan to increase Kazakhstan's steel production is the upgrade of the largest steel mill in Kazakhstan, JSC ArcelorMittal Temirtau, from 4 Mt in 2014 to 6 Mt by 2020, in order to increase efficiency and competitiveness of the factory. This modernisation plan could provide an opportunity for deployment of energy-efficient technologies, including the options discussed in Section 1.3 below.

1.2.2 Residential sector

Energy demand

As shown in Figure 18, the residential sector has been the fastest-growing energy-consuming sector in Kazakhstan over the past seven years. This can mainly be attributed to a growing population and improvements in living standards (as measured by GDP per capita). Nearly half of residential energy use is for space heating. Outside temperature and demand for heating play a significant role in determining the annual energy consumption of the residential sector.

Figure 29 • Housing floor space per capita, Kazakhstan, 2000-14



Source: Committee of Statistics of the Republic of Kazakhstan (2016), population database, www.stat.gov.kz, accessed on 23 June.

Other variable factors that influence demand include population density and living space. According to CENEf (2015), total living space in 2013 amounted to 336 million m^2 or around 19 m^2 per person. Figure 29 shows that per-capita floor space stayed fairly stable over the period

2000-10 with some growth in the few years after, most likely due to strong construction activity in Astana over the past decade.

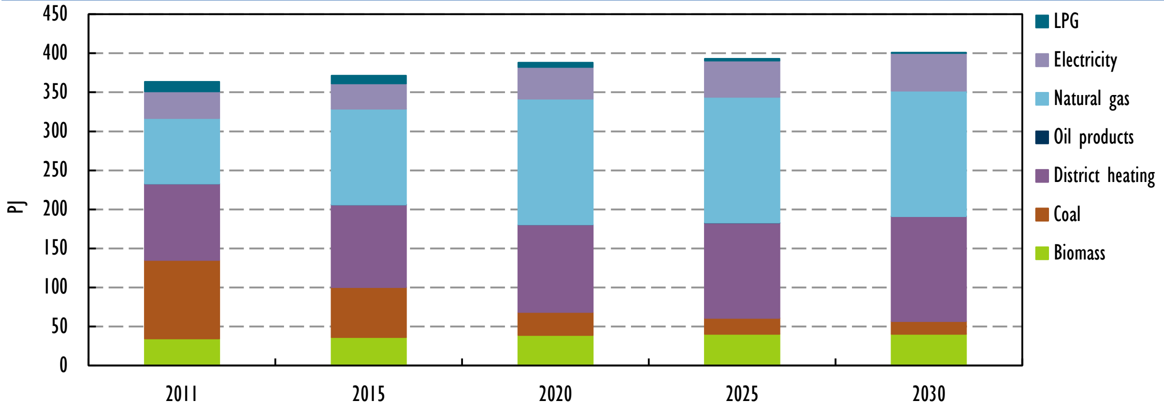
Inefficiencies in building construction and heating systems (overheating and lack of metering) contribute to the high levels of heat consumption in Kazakhstan, similar to other countries from the former Soviet Union in comparable climates (Russia and Belarus, for example). According to the Energy Efficiency 2020 Programme, 32% of the housing stock requires building renovation. According to CENEf (2015), only around 35% of multifamily buildings were equipped with building-level meters by mid-2014 around the country. The share of individual households that have meters for hot water is 81% and nearly 100% for electricity. On average, the level of heat consumption in surveyed homes was 270 kWh/m^2 per year.

Nazarbayev University modelling shows that for the top three energy end-uses, fuels other than electricity tend to dominate the fuel mix for the majority of households (Figure 31). Urban households with access to district heating and gas networks tend to consume gas and heat for water heating and space heating, while many rural households still rely heavily on coal for these purposes, and also for cooking.

Based on estimates of slower population and housing floor space growth, and according to the Nazarbayev University TIMES BAU model results, demand for space heating is not expected to increase significantly. By contrast, residential sector modelling predicts energy demand for other electric appliances and cooling will grow rapidly (by a factor of 2.5 and 2.3, respectively, by 2030 compared to 2011), driven by improving living standards and changing lifestyle habits.

With regard to fuels, the residential sector is expected to consume significantly more natural gas and electricity by 2030 (91% and 41% more in 2030 compared to 2011 levels), without notable expansions in the district heating network. Natural gas use is projected to expand mainly in space and water heating, while electricity is projected to be used more for cooking, lighting and electrical appliances. Natural gas consumption is expected to boom due to a government gasification scheme, adopted in 2014, which plans to expand the gas pipeline network in rural areas, where coal is currently relied upon for heating purposes. Implementation of the scheme is expected to increase gas consumption across all sectors from 10.9 bcm in 2013 to 18.1 bcm by 2030. Consequently, coal consumption is forecast to fall significantly (Figure 30).

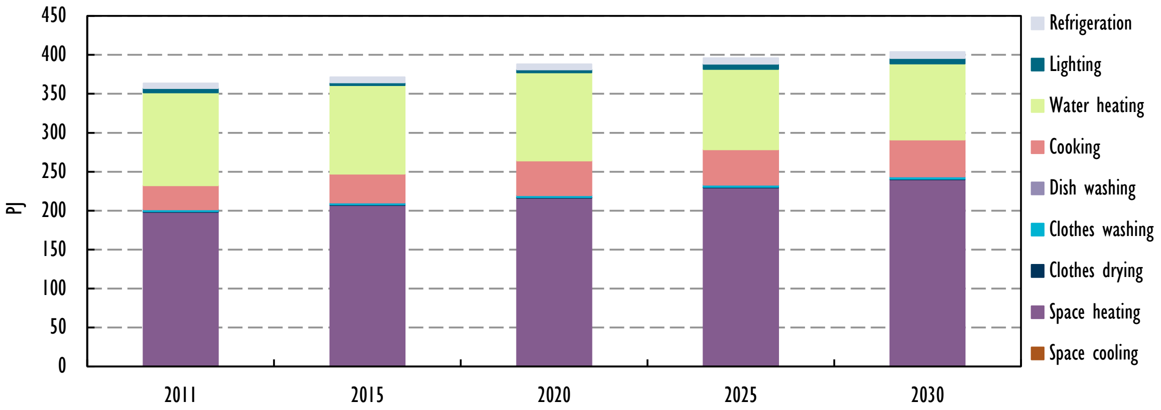
Figure 30 • Projected residential sector energy consumption by fuel to 2030 (BAU), Kazakhstan



Source: TIMES model BAU scenario results, Suleimenov B. et al. (2016), "Exploring pathways for fulfilment of Kazakhstan's INDC targets", presentation, International Energy Workshop 2016, 1-3 June, Cork, Ireland.

The breakdown of end uses in the residential sector is expected to remain relatively unchanged to 2030 (Figure 31).

Figure 31 • Projected residential sector energy consumption by end-use to 2030 (BAU), Kazakhstan



Source: TIMES model BAU scenario results, Suleimenov B. et al. (2016), "Exploring pathways for fulfilment of Kazakhstan's INDC targets", presentation, International Energy Workshop 2016, 1-3 June, Cork, Ireland.

Residential sector policies

According to the Energy Efficiency 2020 Programme, the energy consumption target for the residential sector is a reduction of 20% by 2020 compared to 2011. In order to reach this target, the main area of improvement is the planned refurbishment of the building stock. In 2012, energy efficiency standards and energy efficiency classes were introduced for all buildings. Other energy efficiency mechanisms introduced include: energy metering requirements; energy efficiency standards and labelling for appliances; mandatory energy audits; and energy data reporting. The Law on Energy Conservation and Energy Efficiency requires all new buildings and facilities to have energy and water meters installed while the Law on Natural Monopolies and Regulated Markets requires that all multifamily buildings have heat meters by the end of 2014. (Data was not available for this study to confirm if all necessary meters were installed).

The implementation of energy efficiency measures in the residential sector is expected to be financed from the Housing and Community Services Development Fund, which can provide loans with favourable conditions and financial assistance to applicable projects.

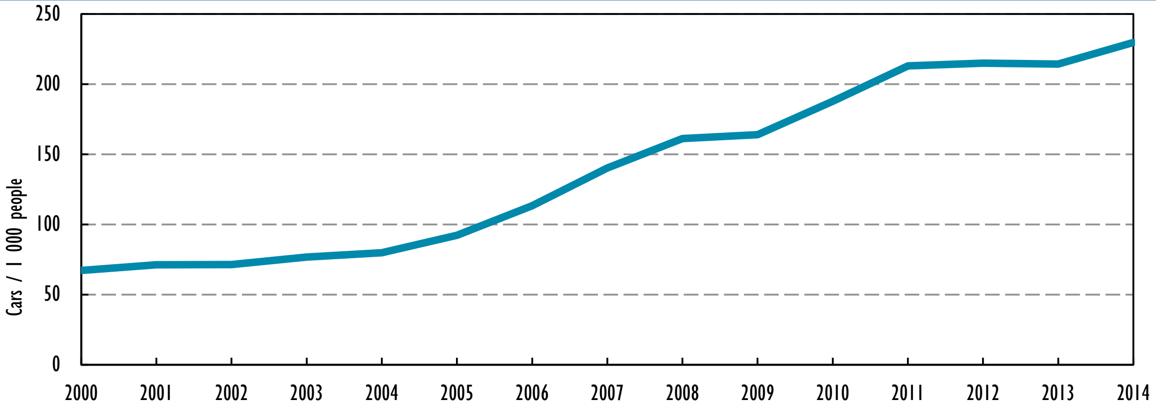
1.2.3 Transport sector

Vehicle fleet

Among the key drivers of demand for transport are population growth, the standard of living, urbanisation, population density and fuel prices. In Kazakhstan, household income growth has led to rapid growth in the number of light-duty vehicles in the country: the number of registered vehicles per 1 000 population has increased from 67.3 in 2000 to 229.7 in 2014, with an average annual growth rate of 8.5% (Figure 32).

This trend has been consistent despite an economic downturn in the country during 2008-09, indicating that factors other than financial play a significant role, including lifestyle changes and the cost and availability of vehicles. Due to Kazakhstan's wide spaces, long distances and low population density, public transport is not yet a viable option. As such, the use of cars has been growing; in 2013, Kazakh citizens bought 163 000 vehicles. Additionally, the automobile manufacturing industry is growing with more than 30 domestic brands, and around 75% of purchased cars are sourced locally or from Russia (without a 30% import tax) (Lee, 2016).

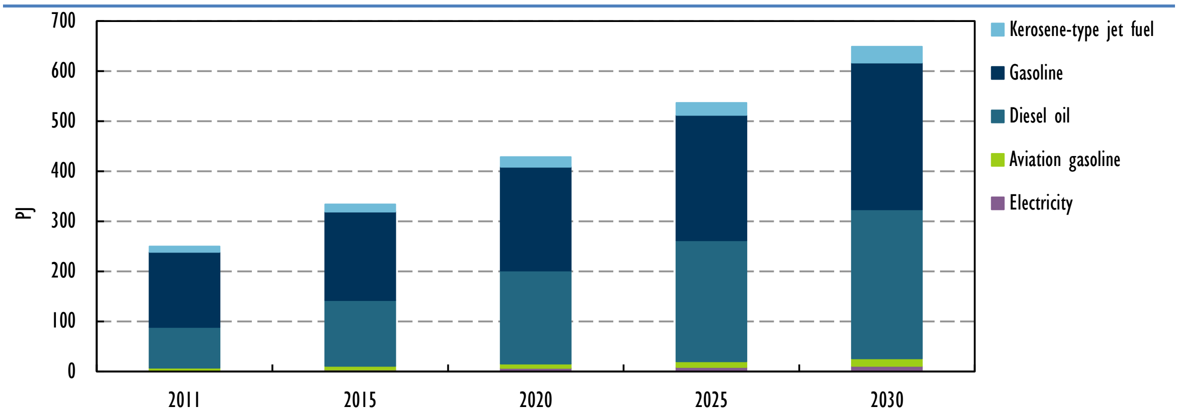
Figure 32 • Number of registered light-duty vehicles per 1 000 population, Kazakhstan, 2000-14



Source: Committee of Statistics of the Republic of Kazakhstan (2016), population database, www.stat.gov.kz, accessed on 23 June.

Nazarbayev University TIMES results for the transport sector under the BAU scenario are shown in Figure 33. Transport sector energy demand grows by a factor of 2.8 for domestic aviation, heavy and light trucks, 2.7 for rail freight and 2.6 for light-duty road vehicle transport. Total energy consumption in the sector is expected to grow 2.6 times by 2030, with gasoline and diesel contributing the highest shares[23]. No significant fuel switching occurs in this sector in the BAU scenario. More efficient gasoline and diesel oil engines start to replace existing stock from 2020.

Figure 33 • Projected transport sector energy consumption to 2030, Kazakhstan



Source: TIMES model BAU scenario results, Suleimenov B. et al. (2016), "Exploring pathways for fulfilment of Kazakhstan's INDC targets", presentation, International Energy Workshop 2016, 1-3 June, Cork, Ireland.

The automotive industry in Kazakhstan is also expected to grow, with Azia Avto (a significant domestic manufacturer) planning to produce more than 40 000 cars for the local market and more than 70 000 cars for the Russian market by 2020 (Lee, 2016).

Transport policy

The main government agency responsible for energy efficiency policies in the transport sector is Ministry of Transport and Communications. Within the Energy Efficiency 2020 Programme, mechanisms to improve energy efficiency in the transport sector include: the introduction of

[23] Oil consumption figures from the Nazarbayev University TIMES model BAU scenario show a significant rise oil consumption by the transport sector to 2030, while the government's Energy Efficiency 2020 plan projects a 30% decline. This indicates that strong government policies and targeted actions are needed in order to reach this ambitious target.

energy efficiency requirements for transport equipment; mandatory energy audits; energy data reporting; fleet replacement; and training in energy expertise.

Among the more detailed measures planned under the programme are:

- the use of solar panels on city passenger buses as an additional source of energy
- study of energy efficiency labelling of tyres
- elaboration of proposals to encourage the purchase of fuel-efficient cars
- study on the abolition of customs duties on cars with hybrid, natural gas and electric motors
- replacement of obsolete aviation fleet engaged on regular flights with more effective types of aircraft with improved fuel economy performance
- study on the use of new passenger diesel locomotives and electric locomotives.

Vehicle fleet and standards

According to the Energy Efficiency 2020 Programme, the average age of the vehicle fleet is about 10 years, with around 9% of the fleet more than 20 years old, and 23% of the fleet less than seven years old. The railway vehicle fleet is considerably older, with most trains operating since the 1960s and 70s.

Under the Energy Efficiency 2020 Programme, the government plans to replace about 50% of the publicly owned vehicle fleet by 2020, focusing mainly on trains and locomotives. The government is also planning to improve the fuel efficiency of new private cars from 12 litres per 100 km (L/100 km) to 7 L/100 km by 2020, while the share of hybrid cars is expected to reach 5% in 2020. Certain European standards for road transport have been adopted, namely Euro 3 and Euro 4 emission standards for light-duty vehicles, with plans to introduce Euro 5 and Euro 6 by 2020.

Changes in the vehicle standards are likely to lead to efficiency improvements; however the government's target to reduce fuel consumption by road, rail and air transport of 30% before 2020, as per the Energy Efficiency Programme, remains challenging in light of the probable increase in the number of vehicles across the population.

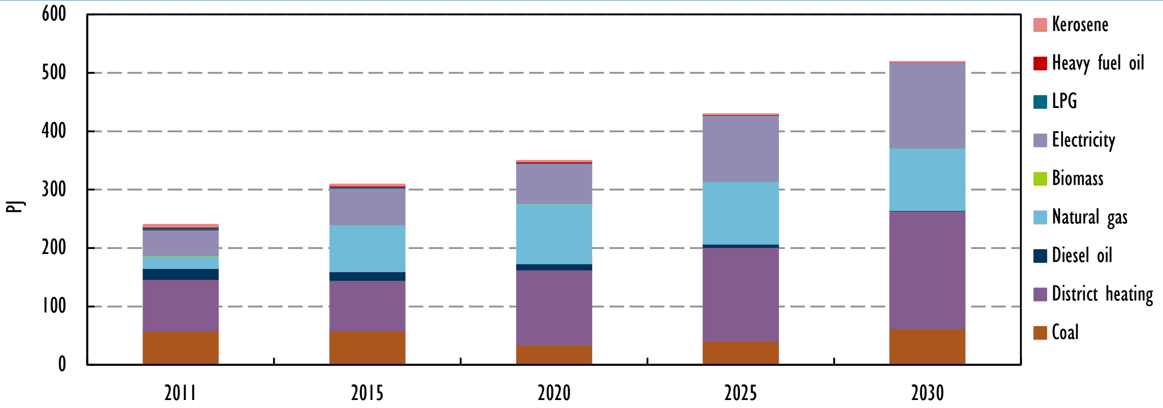
1.2.5 Commercial and public services sector

The commercial and public services sector has similar end-use patterns to the residential sector. Namely, space heating and water heating are the largest consuming end-uses, accounting for two-thirds of energy use, while cooking and lighting are also significant. Therefore, similar demand drivers are relevant in the commercial and residential sectors, primarily climate conditions, floor area per capita, as well as the efficiency of commercial buildings. According to the Energy Efficiency 2020 Programme, the main causes of wasteful energy consumption in public buildings, and therefore indicating potential for improvement, are weak control and management of energy consumption, inefficient building stock and inefficient heating and other appliances, particularly lighting.

Energy consumption in the commercial and public services sector experienced moderate growth of 19% over the seven years to 2014. The Nazarbayev University TIMES BAU scenario results show a two-fold increase in commercial sector energy consumption during 2011-30, driven by significant expansion of the sector (Figure 34). In the modelling, GDP per capita and population growth are the main drivers of future energy consumption in the commercial and public services sector.

In the BAU scenario, electricity consumption in the sector triples by 2030, mainly driven by increasing energy use in water heating, other electric equipment, cooking and lighting. Coal consumption (mainly used for heating) stabilises in the sector, as it is gradually replaced by gas and district heating. The EBRD is currently involved in a number of projects in Kazakhstan supporting the development of an energy efficiency district heating system in the country's northern areas. Consumption of oil products for heating and water heating decreases, while district heating use increases considerably by a factor of 2.3. Unlike the expected boom in gas usage in the rural residential sector, commercial space heating is expected to be connected to existing or new district heating networks, which can efficiently heat large buildings in densely populated areas (provided both the district heating network and the building envelopes are efficient).

Figure 34 • Commercial and public sector energy consumption in the BAU scenario, Kazakhstan, 2011-30



Source: TIMES model BAU scenario results, Suleimenov B. et al. (2016), "Exploring pathways for fulfilment of Kazakhstan's INDC targets", presentation, International Energy Workshop 2016, 1-3 June, Cork, Ireland.

Commercial and public services sector policies

Commercial and public services sector policies are mainly related to the management and regulation of building standards, and are therefore grouped with policies on residential sector energy consumption (see above). The government's particular focus in respect of public buildings is on increasing metering, building retrofits and a strong public awareness campaign on energy conservation.

Energy efficiency in lighting

A further area of policy is the government's plan to improve the energy efficiency of lighting across the residential and commercial service sectors. The target is to reduce the cost of electricity used for lighting by 60% by 2020, with a 100% penetration of efficient light bulbs. Specific measures include:

- upgrading interior lighting in public buildings
- upgrading street lighting in cities and towns
- studying the potential for energy efficiency labelling of lighting products
- implementing pilot projects on energy-efficient lighting
- the development of mechanisms and measures to restrict the supply of inefficient lighting products and to support the demand for energy-efficient products
- exploring phased restrictions on the production and sale of mercury-containing lamps
- changing the sanitary code and the introduction of new technical regulations
- upgrading lighting and electricity systems in high-rise residential buildings with the installation of automatic disconnection devices of the network.

The EBRD is funding several projects on LED street lighting in Kazakhstan, while the UNDP is currently leading a four-year project on the Promotion of Energy-Efficient Lighting in Kazakhstan during 2012-16. This aims to implement the abovementioned measures for more effective market development of energy-efficient lighting and to promote investment in the same (UNDP, 2016a).

Summary of priority subsectors

Table 5 shows the priority subsectors and end-uses selected for further analysis in this study. The industrial, residential, transport and commercial and public services sectors are selected as priorities due to their significant share of total energy consumption and large potential for energy efficiency improvements. Demand growth in the residential, transport and commercial services sectors has been significant over the past decade, while industry is still the largest and most concentrated energy consumer despite stagnant growth.

Iron and steel and non-ferrous metals manufacturing are considered to be priority industry subsectors due not only to their significant energy demand, but also to the high production concentration in a few large facilities. The non-metallic minerals industry (cement and other building materials) accounts for a tenth of industrial energy demand, but is also highly concentrated and linked to significant construction activity in Kazakhstan, primarily Astana. At the global level, the most energy-intensive end-use in industry is process heating, accounting for around 38% of global manufacturing energy use in 2005 (GEA, 2012). In the US iron and steel industry, process heating accounting for around 32% of total fuel consumption in 2006, followed by machine drives, which represented 7% of fuel consumption (EIA, 2016).

End-use consumption in both the residential sector and the commercial and public services sector is mainly driven by space heating, water heating and cooking, but also lighting in the services sector. The building stock in Kazakhstan is primarily more than 30 years old and considered to be inefficient. Road transport is the main transport mode in Kazakhstan, accounting for more than 80% of all transport sector energy consumption, and the one with the largest potential and opportunities for energy efficiency improvement, given its sheer size.

Table 5 • Priority subsectors and end-uses for analysis

Sector:	Transport	Industry	Residential	Commercial
Subsectors:	Road transport	Iron and steel Non-ferrous metals Non-metallic minerals	Buildings	Buildings
End uses:	Passenger vehicles Heavy-duty vehicles	Process heating Machine drives	Space heating Water heating Cooking	Space heating Water heating Cooking Lighting

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 the iron and steel industry (steel mills) and process heating end-use.

The iron and steel industry is the largest energy-consuming industry in Kazakhstan, accounting for 10% of TFC. Its share of TFC has fallen from 12.5% in 2007 due to a decline in production during the economic downturn in 2008-09; however, government plans for the modernisation of the industry are expected to result in growing energy demand in this subsector. In its State Programme for the Industrial Innovation Development for 2015-19, the government lists the iron and steel industry as one of its priority subsectors for development. Modernisation is expected to lead to a 50% increase in steel production (from around 4 Mt to 6 Mt by 2019) if the government programme is fully implemented, offering a significant potential for improvement in energy efficiency and the application of best practice EETs. The steel industry is strongly linked to mechanical engineering and construction, both sectors that are expected to experience growth by 2030 in Kazakhstan.

The following analysis of recent trends in the steel-manufacturing subsector shows which EETs are most appropriate.

1.3 Priority EETs

Using the iron and steel industry as an example, the following sections document some of the steps taken to assemble a preliminary longlist of candidate technologies[24] and then to reduce the longlist to a shortlist.

1.3.1 EET candidate lists

The major energy-consuming processes in the steel industry are: blast furnaces (for the production of pig iron from raw materials such as iron ore and coke); basic oxygen furnaces (BOF) (for the production of primary steel); and electric arc furnaces (EAFs) (for the production of secondary steel from scrap steel, pig iron or direct reduced iron [DRI]). Technical aspects of the three processes are explained in detail in the *Tracking Industrial Energy Efficiency and CO_2 Emissions* publication (IEA, 2007). Improvements in energy consumption of these processes allow for the most potential for efficiency gains in iron and steel making, and the EET candidate list offers a number of priority technologies related to each process, discussed in the following sections.

1.3.2 Results of the EET screening process for prioritisation

The priority EET short list for the iron and steel industry is shown at Figure 35, which also shows these technologies' estimated current market penetration. Results for other industries, the residential, transport and commercial sectors are shown at Annexes B, C, D and E.

To limit the length and complexity of this paper, one technology has been selected to demonstrate the remaining steps of the methodology: scrap preheating for EAFs. The distribution of EAFs is more widespread compared to blast furnaces (which are all located in the largest steel mills), and EAFs are likely to play a role in the growth of the iron and steel industry, at small mills in particular. As shown in the previous section, scrap preheating provides around 10% savings and quick payback periods of one to two years, requiring fewer financial resources (Table 6).

Table 6 • Rating scrap preheating for EAFs against the EET selection criteria

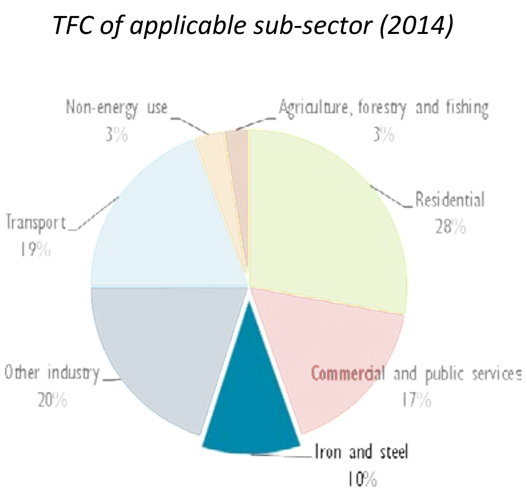
Criteria	Rating
Technical applicability	Medium – Technology is technically applicable to a modest share of energy use within the target sector(s) and end-use(s) based on market structure, growth potential and energy infrastructure

[24] In assembling a longlist of candidate best-practice EETs for assessment in the iron and steel industry, a range of sources was used, including: *Available and Emerging Technologies for Reducing Greenhouse Gas Emissions from the Iron and Steel Industry* (US EPA, 2010); *CO^2 Abatement in the Iron and Steel Industry* (IEA CCC, 2012); *Prospective Scenarios on Energy Efficiency and CO_2 Emissions in the EU Iron and Steel Industry* (Pardo, Moya and Vatopoulos, 2010); *A bottom-up model to estimate the energy efficiency improvement and CO_2 emission reduction potentials in the Chinese iron and steel industry* (Hasanbeigi et al. 2013); *Japanese Technologies for Energy Savings / GHG Emissions Reduction* – 2008 Revised Edition (NEDO, 2008); and *Energy Efficiency Improvement and Cost Saving Opportunities for the US Iron and Steel Industry: An Energy Star Guide for Energy and Plant Managers* (Worrell et al., 2010).

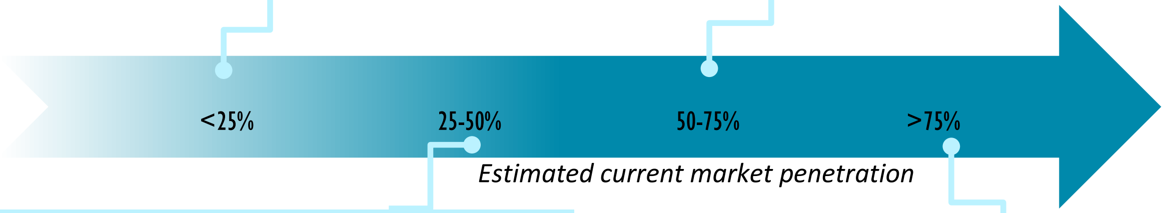
Estimated current penetration	0% - There is no evidence of this technology being deployed in the country.
Absolute saving potential	High – Large energy savings associated with using the technology in comparison to the average technology used
Cost effectiveness	Medium – Cost-effective in niche applications within target or similar sectors and end-uses (e.g. those with high energy prices) compared to reference technology
Diffusion (short-term market potential)	Low – Low diffusion rate is likely due to low stock turnover rate and/or stock contraction, less horizontal technology, a greater number of target adopters, and/or slow market evolution
Maturity	High – Mature technology that is commonly applied to target sector and end-use in international and/or domestic markets

Figure 35 • Priority EETs and estimated current market penetration for the iron and steel industry, Kazakhstan

Energy Savings	Process	Technology
★★★	Hot stove	Waste heat recuperator on hot blast stove
★	Blast furnace	Top pressure recovery turbines
★★	Blast furnace	Injection of coke oven gas/basic oxygen gas
★★	Blast furnace	Heat recovery from slag
★★★	Electric arc furnace	Contiarc furnace
★★	Electric arc furnace	DC arc furnace
★★★	Electric arc furnace	Scrap preheating
★★	Electric arc furnace	Eccentric bottom tapping on existing furnace
★★★	Electric arc furnace	Transformer efficiency - ultra high power transformers
★★★	Electric arc furnace	Flue gas monitoring and control
★★★	Electric arc furnace	Waste heat recovery
★★★	Basic oxygen furnace	Waste heat and gas recovery
★★★	Hot rolling	process control in hot strip mill
★★	Hot rolling	Insulation of reheating furnace
★★	Hot rolling	Recuperative burners



Energy Savings	Process	Technology
★★★	Coke oven	Heat recovery of coke oven gas



Energy savings	Process	Technology
★★★	Sintering	Utilisation of waste fuels
★★★	Blast furnace	Blast furnace gas recovery
★★	Blast furnace	Pulverised coal injection (to 130 kg/tonne iron)
★★	Hot stove	Hot blast stove automation
★★	Hot stove	Improved hot stove combustion control

Energy Savings	Process	Technology
★★★	Quenching	Coke Dry Quenching / Coke Stabilised Quenching
★★★	Coal preparation	Coal Moisture control
★★★	Coke oven	Top gas utilisation (coke oven gas recovery)

1.3.3 Enabling factors for market success

In addition to the criteria in Table 6, deployment of scrap preheating technologies 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 Identify appropriate energy indicators

According to the IEA (2014), the energy efficiency of an iron and steel plant is largely influenced by the type of process used and the amount of scrap in the feedstock. For the purposes of energy indicators, the energy input of the iron and steel subsector should include the consumption of fuels in coke ovens and blast furnaces, but should not include by-products of the process (e.g. coke oven gas, blast furnace gas and basic oxygen furnace gas) that are sold and not used on site.

There are six IEA-recommended energy indicators for the industry subsector level (iron and steel manufacturing industry for the purpose of this study) (Table 7). The IEA preferred indicator is the subsectoral energy consumption per unit of subsectoral physical output (IS2a in Table 7). Physical output is the total physical production of a given subsector (e.g. the quantity of steel produced by the iron and steel sector), generally measured in volume or mass, depending on the product. For Kazakhstan, the possible energy efficiency indicator for the iron and steel industry is the TFC in iron and steel per million tonnes of steel output:

- 2014: 3.9 Mtoe/4 Mt = 0.98 Mtoe of energy per 1 Mt of steel production.

Table 7 • Energy indicator at subsectoral level

Indicator	Source of information
IS1a: Total subsectoral energy consumption (absolute or as a share of industry consumption)	Energy balances and national statistics
IS1b: Share of each energy source in total subsectoral energy consumption mix	Energy balances and national statistics
IS2a: Subsectoral energy consumption per unit of subsectoral physical output	Energy balances and national statistics
IS2b: Subsectoral energy consumption per subsectoral value added	Energy balances and national accounts
IS3a: For each process/product type: energy consumption per unit of physical output	Industry energy data survey
IS3b: For each process/product type: energy consumption per value added	Industry energy data survey

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

However, a broad-based comparison of total subsector energy use per tonne of crude steel is of limited use because the production processes are very different. BOF and EAF processes need to be treated separately, as should the DRI processes (IEA, 2007). Therefore, indicators IS3a and IS3b are preferable in this iron and steel subsector; however, they are more difficult to measure and more time and resource consuming. The National Committee on Statistics currently collects data on the level of output per product type; however, data are not presently available on the level of energy consumption per product type.

2.2 EET penetration metrics

Consistent with CETAM (IEA, 2016), EET penetration indicators should be expressed per unit of the activity that is used in the chosen energy indicator for the priority end-use. In the case of iron and steel, the chosen unit of activity for the energy indicator is Mt of steel production. However, as there are different processes in the industry producing different types of products, Mt of steel production is not the ideal unit of activity for the desired EET penetration metric.

As mentioned in the previous section, the ideal unit of activity would be process-specific. For the purpose of this study, that would be Mt of primary steel produced (for the BOF route) and Mt of secondary steel produced (for the EAF route). The most direct approach to measuring the level of penetration of the chosen technology would then be to measure the share of EAF steel produced with the use of scrap preheating.

In order to develop the desired metric of market penetration, data on EAF steel production and the number of EAFs that use scrap preheating can be collated through industry surveys and national production surveys. According to sources at the Nazarbayev University, three steel mills in Kazakhstan have an EAF with none using scrap preheating.

Step 3: Technology monitoring system

The monitoring of priority EET markets involves establishing a baseline or reference indicator value against which to measure changes in penetration over time, as well as savings from the use of the technology. It requires the identification of sources of data on EET penetration in the selected subsectors. In the case of scrap preheating for EAFs in Kazakhstan, the baseline reference indicator is zero. It is also advisable to track overall trends in energy efficiency indicators over time, in an attempt to better understand the link between the EET penetration indicator and the trends in energy use.

An example for Kazakhstan would be tracking the indicator that measures EAF process-specific energy consumption per tonne of secondary steel, along with the selected metric for measuring the penetration of EAFs with scrap preheating.

3.1 Data collection system

There is a 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. Energy balances are already available in Kazakhstan, and the Nazarbayev University TIMES model provides the possibility of modelling different technology penetration levels.

Overall, it is important that the country develop a stable and consistent data collection method for tracking energy efficiency indicators and EET penetration levels, and Table 8 suggests elements to be considered that are in addition to existing data. 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 made available for collecting those data.

Table 8 • Suggested data collection system for tracking market penetration of scrap preheating for EAFs, Kazakhstan

Data type	Responsible entity	Collection method	Collection frequency	Quality control
Energy balances	The Committee on Statistics	Energy balance	1 year	Internal
Energy efficiency indicators	The Committee on Statistics	Energy balance	1 year	Internal
EAF process energy consumption	The Committee on Statistics, industry associations	Industry surveys, energy audits	1-2 years	Internal
Value-added data	The Committee on Statistics	National accounts	1 year	Internal

EAF steel production output	Industry associations, manufacturers	Industry surveys, energy audits	1-2 years	External audit
EAFs and scrap preheating equipment	Industry associations, manufacturers	Industry surveys, energy audits, sales data	1-2 years	External audit

Under the State Programme for the Industrial Innovation Development of Kazakhstan for 2015-19, it is envisaged that monitoring of the results of the programme will take place towards the end of the five years. However, in order to track progress sooner, the government has established a monitoring department within the Ministry of Industry and New Technologies, reporting on quarterly progress. As part of the programme monitoring and evaluation of results, the level of penetration of new and existing technologies in highly concentrated industries such as iron and steel could be possible.

3.2 Key enabling factors for monitoring

The evolution of market penetration of scrap preheating for EAFs in Kazakhstan will depend on a number of enabling factors, which are discussed below according to type.

Regulatory and institutional factors

The Law on Energy Conservation and Energy Efficiency is the main primary legislation governing energy efficiency measures in Kazakhstan. There are also energy efficiency building codes and more than 22 regulations (CENEf, 2015), including:

- the Energy Efficiency 2020 Programme (2013)
- the Comprehensive Energy Conservation Plan to 2015 (2013)
- the Decree on Setting Energy Consumption Norms to Manufacture Some Industrial Products (2012)
- the Decree on Approval of Energy Efficiency Requirements to Predesign and Design Documentation on Buildings, Constructions and Facilities (2012).

The major government body responsible for implementation of energy efficiency policies is the Ministry of Investment and Development. Other responsible bodies include the Ministry of Education and Science, the Committee on Construction, the Ministry of Transport and Communications, Housing and Communal Sector and Land Resources Management, the Agency on Natural Monopolies Regulation, the Construction and Communal Services Agency, the Committee on Energy Inspection and Control, the JSC Institute of Electricity Development and Energy Saving, the Kazakhstan Energy Auditors Association and the Electric Power Association (CENEf, 2015).

Under the Law on Energy Conservation and Energy Efficiency all energy users whose annual energy consumption is above 1.5 million tonnes of coal-equivalent are mandated to have energy management systems. Since the introduction of the law, the government has (UNDP and GEF, 2015):

- initiated over 3 000 energy standards for industrial and energy companies, public buildings and the transport sector, including electric vehicles for public transport
- launched 200 technical standards for energy efficiency
- revised building regulations to introduce energy efficiency standards in buildings
- introduced efficiency classes for buildings

- established control and monitoring mechanisms for implementation of energy efficiency policies and measures, and established a state energy registry for large (mainly public) energy consumers.

In 2015, the government approved the State Programme for the Industrial Innovation Development of Kazakhstan for 2015-19, which replaced the previous five-year programme, aimed at modernising and improving the efficiency of the industrial sector. With regard to the iron and steel industry, the government recognises the following main issues:

- low utilisation of production capacity in existing enterprises
- high degree of nearly obsolete equipment
- underdeveloped domestic market
- falling exports and increased imports of products with high added value
- poor quality and narrow range of manufactured products
- the absence of test bases and laboratories for certification of products
- high energy and labour intensity of production
- low level of transport and logistics infrastructure
- lack of qualified personnel
- need for modernisation of material and technical bases and pilot sectoral institutions.

In order to combat the mentioned issues, the government's aim is to improve competitiveness through diversification and modernisation, as well as to encourage innovation to improve the quality of products, to increase productivity and to reduce the energy intensity of production (among other measures).

The current focus on modernising the industrial sector and curbing demand growth will improve the likelihood of an increase in penetration of scrap preheating for EAFs.

Financial and market factors

According to the Energy Efficiency 2020 Programme, around USD 18 million of budget funding is planned to be spent on industrial sector measures, albeit the full cost of the programme is expected to be funded through both private and public investment and loans.

Financial and market factors for the development of energy efficiency measures and investment in EETs in the industry sector are weak at present. There is no one dedicated fund responsible for financial assistance of energy efficiency programmes, and no specific financial instrument for offering loans with favourable options to enterprises for investment in planned measures.

Without strong financial incentives, including favourable loans, grants and other financial assistance, investment in scrap preheating for EAFs by existing and new steel makers is likely to be slower.

Technical and infrastructure factors

No particular infrastructure or technical restrictions apply to the implementation of scrap preheating for EAFs. The restrictions lay in the technical specifics of the particular processes of each facility. The IEA publication *Tracking Industrial Energy Efficiency and CO_2 Emissions* (2007) provides a detailed analysis of the technical aspects and technologies used in different types of iron and steel processes.

Lessons learned from the pilot study

Data quality review

The main sources of information for the EET analysis for Kazakhstan, including projections, have been the annual balance data estimates by the Nazarbayev University and results of their TIMES BAU modelling. The IEA collects annual balances from Kazakhstan; however, as the Nazarbayev University has provided a more detailed analysis of estimated sector end-use for the energy efficiency section of the report, for the purposes of consistency the renewables section also reflects estimates from the same database. It has been noted that Kazakhstan's balances data submitted to the IEA are incomplete and inconsistent with the Nazarbayev University estimates. The IEA is consistently working with the government of Kazakhstan to improve data collection and quality.

Certain data were sourced through secondary research, with the sources referenced throughout the report. The majority of the information gathered on policy developments has been gathered through secondary research.

Recommendations on future users of the methodology in Kazakhstan

Given that the Ministry of Industry and New Technologies has the responsibility of implementing EETs in Kazakhstan, it is the logical agency to use the methodology in future, to develop the necessary energy efficiency indicators and to monitor them. The Nazarbayev University TIMES model should be used to continue to update the priority energy efficiency technology list periodically (every three to five years), in order to have a full overview of best practice technologies and how their applicability to the Kazakh market and their market penetration changes over time.

Conclusions

RETs

Kazakhstan's renewable energy potential is considered to be vast, mainly in solar and wind power generation. As an oil- and coal-producing country with a dry climate, one of the government's main areas of concern is climate change and reducing GHG emissions, including from the energy sector. As such, the country is dedicated to developing energy sources apart from coal, including a greater focus on gas and renewables, and potentially nuclear energy. However, challenges remain in attracting investment in renewables development due to plentiful, inexpensive coal and oil, fossil fuel subsidies and lack of supportive financing mechanisms and innovative business models. The following strengths and areas of improvement summarise the key conclusions reached during the pilot study:

Strengths include:

- significant resource potential
- strong strategic drive towards reducing reliance on oil and coal
- improving legislative framework regarding foreign investment
- planned changes to the feed-in tariffs that mitigate currency fluctuation risks and create more certainty for investors
- government focus on renewables, to be highlighted at the Expo 2017.

Suggested areas for improvement include:

- improving the enabling environment for renewables by strengthening legislation on grid integration rules and reducing barriers for new renewables generators
- increasing public awareness of the benefits of renewables, and further improving transparency of the renewables market factors for private and foreign investors.

EETs

The potential for energy efficiency in Kazakhstan is considerable, given the aged infrastructure inherited from the Soviet Union, and the extreme climatic conditions which require significant resources. As energy demand is set to grow over the medium term, due to improving living standards, the government has prioritised energy efficiency and energy-saving measures in order to curb demand growth, with a particular focus on the energy-intensive industrial sector. The following strengths and areas of improvement summarise the key conclusions reached during the pilot study:

Strengths include:

- strong government focus and dedication to energy savings, with recently adopted and sector-wide energy efficiency and consumption standards and codes
- modernisation of the industry sector under way
- government focus on energy efficiency, to be highlighted at the Expo 2017.

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
- phasing out fossil fuel subsidies, while ensuring the social impacts are minimised through targeted support for vulnerable customers.

Annex A. Results of the EET prioritisation screening methodology

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

Industry short-list for Kazakhstan

Residential building short-list for Kazakhstan

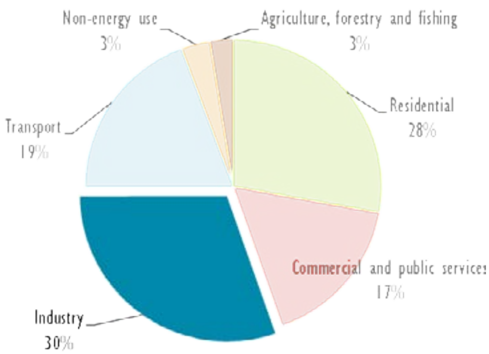
Commercial buildings short list for Kazakhstan

Transport short-list for Kazakhstan

The information contained in this Annex is based on data gathered by the IEA including through consultation with the EBRD and relevant parties in Kazakhstan, and it is provided on an "as available" basis. This paper and its Annexes do not constitute advice on any specific issue or situation and it is not intended to be relied upon in making any decisions.

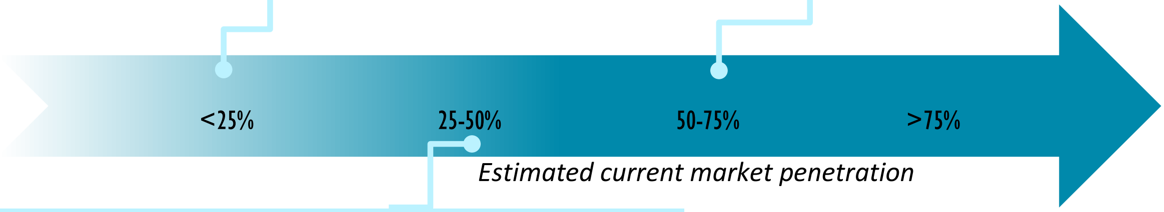
Annex B. Estimated market penetration of industry sector priority cross-cutting EETs

TFC of applicable sub-sector (2014)



Energy Savings	End Use	Technology
★★★	Refrigeration	Improved compressor / heat exchanger
★★	Refrigeration	Improved insulation
★★	Compressed air systems	Install dedicated storage with metered recovery

Energy savings	End Use	Technology
★★★	Furnaces	Improved process controls (e.g. air-to-fuel ratio)



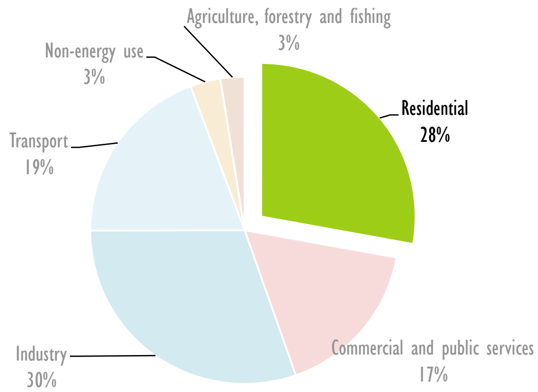
Estimated current market penetration

Energy savings	End Use	Technology
★★★	Boilers	Improved process control (including flue gas monitoring)
★★★	Boilers	Feedwater economiser
★★★	Boilers	Return condensate
★★★	Furnaces	Efficient design burners (e.g. low NOx)
★★★	Pumps	Install variable speed drive
★★★	Pumps	More efficient pump
★★★	Pumps	More efficient motor
★★★	Fan	Install variable speed drive
★★★	Fan	Replace oversized fans with more efficient type
★★★	Compressed air systems	Variable speed drive
★★★	Compressed air systems	Improvement of automatic control

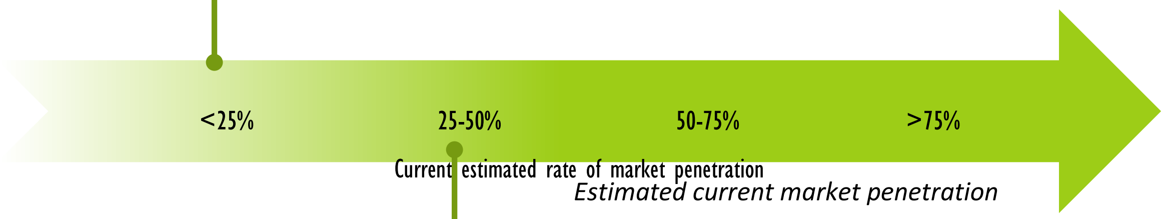
Notes: The estimated current market penetration rates and energy savings for these technologies are based on expert judgement; these estimates do not represent the views of the IEA; the star ratings indicate where energy savings from deploying the technology are estimated to be high (3 stars), medium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

Annex C. Estimated market penetration of residential buildings sector priority EETs

TFC of applicable sub-sector (2014)



Energy savings	End use	Technology
★★★	Cooking	Induction cookstove
★★★	Space heating	Electric heat pump - EU labelling - A
★★★	Space heating	Electric heat pump - EU labelling - A+
★★★	Space heating	CHP (reciprocating engine)
★★★	Space heating	Loft insulation (200 to 300 mm)



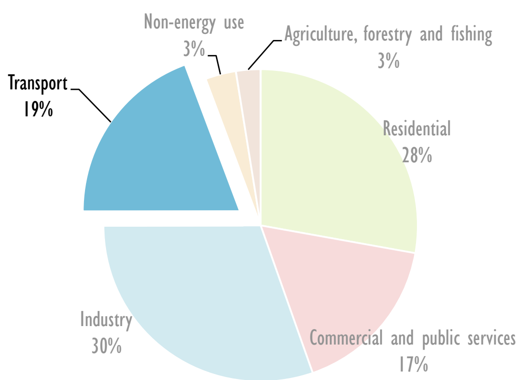
Energy savings	End use	Technology
★★★	Space heating	Loft insulation (100 to 200mm)
★★★	Space heating	Floor insulation
★★★	Space heating	Double glazing windows
★★★	Space heating	Solid wall insulation
★★★	Lighting	CFL bulb
★★★	Lighting	LED

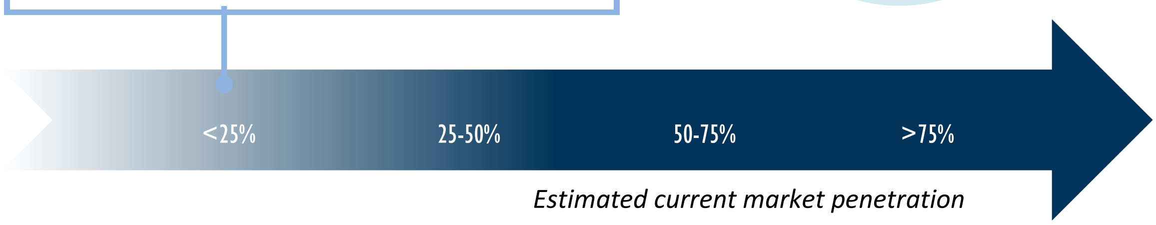
Notes: The estimated current market penetration rates and energy savings for these technologies are based on expert judgement provided by members of the Nazarbayev University; these estimates do not represent the views of the IEA; the star ratings indicate where energy savings from deploying the technology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

Annex D. Estimated market penetration of transport sector priority EETs

Energy Savings	End Use	Technology
★★★	Vehicle modifications	Tyres: low rolling resistance
★★★	Vehicle modifications	Lightweighting (high-strength steel)
★★★	Vehicle modifications	Dual clutch transmission
★★★	Vehicle modifications	Lightweighting (aluminium)
★★★	Vehicle switching	Electric vehicles
★★★	Vehicle switching	Fuel cell electric vehicles
★★	Vehicle switching	Mild hybrid (start-stop system recuperation)
★★	Vehicle modifications	Engine low friction design and materials
★★	Vehicle modifications	Lightweight components other than Body in White (BIW)
★★	Vehicle modifications	Variable valve actuation and lift
★★	Vehicle modifications	Starter-alternator (increased battery)
★★	Vehicle modifications	Aerodynamics - spoilers
★★	Vehicle modifications	Aerodynamics - front air dams
★★	Vehicle modifications	Aerodynamics - side skirts
★★	Vehicle modifications	Aerodynamics - under-body panels
★★	Vehicle modifications	Direct injection

TFC of applicable sub-sector (2014)

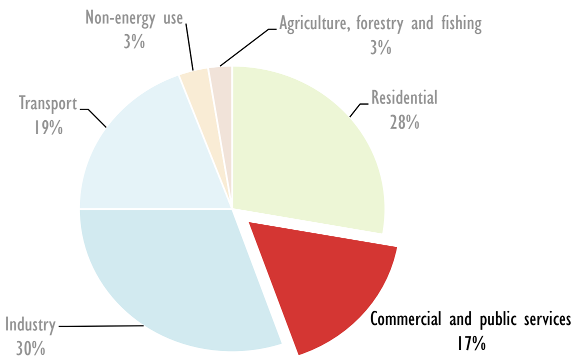


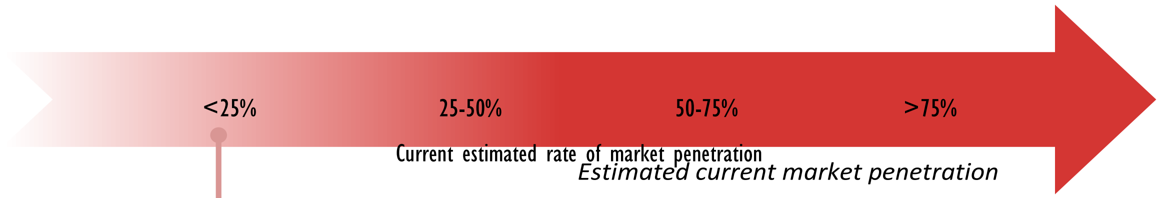


Notes: The estimated current market penetration rates and energy savings for these technologies are based on expert judgement provided by members of the Nazarbayev University; these estimates do not represent the views of the IEA; the star ratings indicate where energy savings from deploying the technology 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.

Annex E. Estimated market penetration of commercial buildings sector priority EETs

TFC of applicable sub-sector (2014)





Estimated current market penetration

Energy savings	End use	Technology
★★★	Lighting	LED
★★★	Lighting	High-intensity discharge lamps
★★★	Lighting	Presence sensors
★★★	Appliances	Refrigerators - EU labelling - A++
★★★	Appliances	Refrigerators - EU labelling - A+++
★★★	Appliances	Dishwashers - EU labelling - A++
★★★	Appliances	Dishwashers - EU labelling - A+++
★★★	Appliances	Televisions - EU labelling - A++
★★★	Appliances	Televisions - EU labelling - A+++
★★★	Appliances	Washing machines - EU labelling - A+++
★★★	Appliances	Clothes driers - EU labelling - A
★★★	Appliances	Combined washer driers - EU labelling - A
★★★	Space cooling	Air conditioner - EU labelling - A
★★★	Space cooling	Air heat pump - EU labelling - A
★★★	Space cooling	Triple glazed windows
★★★	Space cooling	Low-E windows
★★★	Heating	Conventional water heater - EU labelling - A
★★★	Water heating	Solar water heater - EU labelling - A
★★★	Water heating	Heat pump water heater - EU labelling - A
★★★	Water heating	Hot water storage tank - EU labelling - A
★★	Space cooling	Reflective walls/roofs
★★	Space cooling	Window attachments (highly insulating, e.g. cellular shades, low-e films)

Notes: The estimated current market penetration rates and energy savings for these technologies are based on expert judgement; 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).

Acronyms, abbreviations and units of measure

Acronyms and abbreviations

BAU	business as usual
BOF	basic oxygen furnace
CGE	computable general equilibrium model
CETAM	Clean Energy Technology Assessment Methodology
CENEF	Centre Européen de Formation
CES	Common Economic Space
CO_2	carbon dioxide
COP 21	The 21st session of the Conference of the Parties to the UNFCCC
CSP	concentrated solar power
DNI	direct normal irradiance
DRI	direct reduced iron
EAF	electric arc furnace
EBRD	European Bank for Reconstruction and Development
EEC	Eurasian Economic Commission
EET	energy efficiency technology
EEU	Eurasian Economic Union
EIA	Energy Information Administration (United States)
ESCO	energy service company
ETC	early transition country
ETS	emissions trading scheme
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
GEA	Global Energy Assessment
GEF	Global Environment Facility
GHG	greenhouse gas
HDV	heavy-duty vehicle
HFT	heavy-freight truck
ICAP	International Carbon Action Partnership
ICE	internal combustion engine
IEA	International Energy Agency
IEA CCC	IEA Clean Coal Centre
IMF	International Monetary Fund
INDC	intended nationally determined contribution
KEGOC	Kazakhstan Electricity Grid Operation Company

LCOE	levelised cost of electricity
LED	light-emitting diode
MFT	medium-freight truck
MSW	municipal solid waste
NEA	Nuclear Energy Agency
NEDO	New Energy and Industrial Technology Development Organisation
NURIS	Nazarbayev University Research and Innovation System
OECD	Organisation for Economic Co-operation and Development
PV	photovoltaic
R&D	research and development
REEEP	Renewable Energy and Energy Efficiency Partnership
SEMED	Southern and Eastern Mediterranean
TFC	total final consumption
TPES	total primary energy supply
USD	United States dollar
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
US EPA	United States Environmental Protection Agency
WTO	World Trade Organization
WACC	weighted average cost of capital

Units of measure

bcm	billion cubic metres
GJ/t	gigajoules over tonne
GW	gigawatt
GWh	gigawatt hour
EJ	exajoules
km	kilometre
kWh	kilowatt hour
kWh/m^2	kilowatt hours per square metre
kWh/t	kilowatt hours per tonne
m	metre
m^3	cubic metre
MHa	million hectares
MWh	megawatt hour
MWth	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
TWh	terawatt-hour
W	watt

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Clean Energy Technology Assessment Methodology Pilot Study

Kazakhstan

Oil exports play a major role in the economic development of Kazakhstan, the largest petroleum producer in Central Asia. But the country's vast plains also hold significant renewable energy potential that remains largely untouched, particularly solar and wind power. This major potential could help the country reach its ambitious goals of diversifying most of its electricity generation away from coal use while cutting harmful greenhouse gas emissions. Improving the country's ageing Soviet-era infrastructure also holds significant promise for advancing energy efficiency.

The International Energy Agency selected Kazakhstan as a key player in regional efforts to deploy low carbon technologies in Central Asia for a pilot study developed with the European Bank of Reconstruction and Development. This Clean Energy Technology Assessment Methodology programme aims to provide clear and transparent information about renewable energy and energy efficiency technology markets, with the goal of identifying the most promising technologies for policy support and investment and establishing metrics for tracking their deployment over time.

This report assesses a range of technological options in Kazakhstan 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 effective renewables deployment and grid integration would help Kazakhstan reach its diversification targets sooner. Phasing-out of energy subsidies and developing in-depth monitoring indicators would allow the country to better track the implementation of planned energy efficiency measures and optimise its energy savings potential.