June 2023

Energy Transition in Monocities. Coal Phase-out Roadmap and Just Transition Action Plan for Ekibastuz (Kazakhstan)

2030 Roadmap and Action Plan

For the project: **Post-Crisis Support to the Government's Reform Initiatives**

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Authors: **Elizaveta Kuznetsova and Kathleen Vaillancourt**

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Executive Summary

Kazakhstan is an upper middle-income country whose economic growth since independence has largely depended on fossil fuel exploitation. The country has taken progressive steps to promote sustainable development, setting ambitious goals in the *Kazakhstan 2050 National Development Strategy* and the *Green Economy Concept*. These documents serve as the country's strategic vision for inclusive sustainable development. The strategy lays the foundation for the implementation of the goals of the Paris Agreement and determines national approaches, a strategic course of state policy for the consistent transformation of the economy of the Republic of Kazakhstan, considering relevant opportunities and risks. One of the key sectors for achieving carbon neutrality is the energy sector, which is the largest contributor to Green House Gas (GHG) emissions in the Republic of Kazakhstan. The main source of GHG emissions is the coal industry, which was responsible for 65% of GHG emissions in the energy sector in 1990 and for 59% in 2017, despite its moderate share in total energy supply. Today, Kazakhstan is among the ten countries with the largest coal reserves in the world with 33.6 billion tons of viable reserves (about 400 coal deposits). About 72% of the country's coal is mined in the Karaganda and Pavlodar regions. In 2020, 30,260 people were directly employed in the coal mining sector.

The reduction of coal requires an expansion of alternative energy sources, with natural gas playing a key role as an interim solution and to provide maneuvering capacity for the renewable energy sector. Situated in the top 20 countries in terms of its overall gas resources estimated to 2.3 trillion cubic meters as of the end of 2020, Kazakhstan may opt for the expansion of its national gas market for phasing-out coal as the first step towards carbon neutrality. A successful coal-to-gas switch needs to rely on Roadmap and Just Transition action plan reconciling environmental targets with other concerns (such as energy affordability, supply resiliency, employment, and industry competitiveness). This report summarizes quantitative insights regarding effects of coal phase-out, country gasification and renewable sources deployment at country level by making a specific focus on the mid-term transition phase (up to 2030). It provides the analysis of the Carbon Neutrality Strategy risks and benefits for the city of Ekibastuz, a monocity hosting biggest open pit coal mines.

Major findings

Coal economics and industry competitiveness:

- While the share of coal mining added value in regional GDP is small (the maximum being 2.5% in Pavlodar region), coal phase-out may have an important impact on industry relying on coal, especially in coal-dependent communities.
- At the same time, measures, such as EU's Carbon Border Adjustment (CBAM), will considerably impact Kazakhstan industry in the absence of coal phase-out. In 2024 Kazakhstan may lose over USD 250 Million in export receipt and, under the increase EU carbon price, over USD 400 Million in 2025.

Marketable gas supply:

- An eventual moratorium on gas export to supply the domestic market and strong tariff regulation (keeping gas tariffs low) will lead to major financial losses for the National Gas Operator (QazaqGaz). According to our estimations the losses will overcome the announced KTZ 1,000 Billion between 2022 and 2026.

- Absence of price incentive (low end-use tariffs) creates the risk for marketable gas shortage in the domestic market. Moreover, 70% of produced gas is associated gas, part which is re-injected in oil reservoirs. Re-injection is supposed to increase from 36% to up to 50% after 2025.

National energy tariffs and energy affordability in residential sector:

- Coal is the most expensive fuel with the least regulated price. The cheapest energy for heating end-use is central heating, followed by natural gas.
- Tariffs in Kazakhstan are highly dependent on the region and are very disperse creating issues for costs equity and fairness. Household using different fuels to satisfy the same end-use in different regions with similar weather pay different bills (energy cost may differ by a factor of two).
- According to our calculations gas tariffs must be substantially higher to support country gasification: gas tariff must be already now twicer higher than the tariff in place.
- Energy affordability subsidies will be required to prevent energy poverty among low-income families for poor households. Ekibastuz will need around USD 600,000 to support equipment replacement and gas connection for households and up to USD 60,000 annually to support low-income households in payment of their bills in case of tariffs increase.

Energy transition of power and heat energy sector:

- According to the Carbon Neutrality Strategy, coal-based power and heat generation must drop by almost 50% by 2030. At the same time, by 2030 the share of renewable generation (wind and solar) must represent about 31% in the total generation mix.
- Kazakhstan in general holds an excellent potential for wind and solar power generation. Ekibastuz potential is comparable with cities, such as Freiburg (Germany), leading in adoption of renewable energies.
- The deployment of distributed solar and wind generation may considerably reduce electricity bills for Ekibastuz residents. Season storage based on hydrogen may help to gain some heating autonomy going up to several weeks in case of heat network failures.

Employment:

- The Carbon Neutrality Strategy creates a substantial labor demand. In Kazakhstan clean sectors may create more than 60,000 jobs, while coal production sector may lose about 15,000 jobs by 2030.
- If coal mines in Ekibastuz follow the Carbon Neutrality Strategy, employment in coal mines near the city may decrease from 12,000 in 2020 to about 7,220 workers in 2030, around 3,300 workers must be supported for re-employment in other sectors.
- At the same time, the deployment and operation of renewable generators will be able to counterbalance employment decrease in the coal sector and to create the opportunity for labor transition.

Health issues:

- Coal phase-out in energy production and use will help to decrease related diseases. In 2018, Karaganda and Pavlodar regions recorded 239 and 263 cancers cases, respectively, per 100,000 population, while the national average was 184 cases per 100,000 population.
- According to the recent satellite observations, 27,500 kg/h of methane emissions were observed coming from Ekibastuz mines in October 2021, 45,289 kg/h of methane were observed coming from Bogatyr mine in January 2022. In March 2022, Bogatyr mine in Kazakhstan totaled 54,000 kg/h of methane emissions representing the emissions of around 2.6 million cars driving for a year.

Content

From the National Carbon Neutrality Strategy

In 2020, Kazakhstan has committed to achieve a carbon neutrality goal by 2060 [1]. The pathway to such ambitious objectives relies on several major pillars:

- To phase-out coal by 2050 (including direct coal consumption by households and other consumers and coal-fired power generation); coal power generation share supposes to decrease from 67.3% in 2020 by about 30% by 2030 before to be completely phase-out by 2050.
- To expand national natural gas infrastructure transmission and distribution network to specifically support coal-phase out in coal production regions, such as Pavlodar and Karaganda; country natural gas-fired power generation is planned to be increased from 21.7% in 2020 to about 35% by 2030.
- To expand power generation with renewable energy sources that must progressively increase from less than 3% in 2020 to 15% by 2030, and take the leading role in power generation with the power generation share of more than 80% by 2060 (not including large hydropower).

This report is structured in the way that the impact of the Carbon Neutrality strategy, such as macroeconomic impact, industry competitiveness; energy affordability and employment, is analysed first at the country level. Each section starts with the recall of the Kazakhstan status in relation with different topics and continues with the analysis of risks and benefits from the Carbon Neutrality Strategy at the level of Kazakhstan.

To the local community of Ekibastuz

Country level analysis is followed by the analysis of risks and benefits for Ekibastuz (Pavlodar region). Qualified by the Government as a monocity, where the main part of industrial production and the working population is concentrated in one or several city-forming enterprises, Ekibastuz is the part of the Development Program for Monocities. The program is focused on identification of monocities specific risks and implementation of different projects aiming to reduce these risks. This reports partly covers these risks and illustrates how the Carbon Neutrality Strategy may be used for monocities development.

The report is concluded by the Roadmap and Action plan to guide the first stage of energy transition and mitigate the associated risks. These policies may be responsibility of different authorities and applicable at different levels (city, regional and federal).

Major limitation:

- In the absence of explicit data quantifying energy demand and use of commercial and industrial sectors, the analysis focuses mainly on residential sector. To establish a clear and coherent energy transition plan compliant with the Carbon Neutrality Strategy and various sectors needs, the analysis of commercial and industrial sectors in Ekibastuz will be required.

THE PROGRAM FOR MONOCITIES DEVELOPMENT IN KAZAKHSTAN

By definition, a monotown is a city where the main part (20% or more) of industrial production and the working population is concentrated in one or several (few) city-forming enterprises, as a rule, of the same profile and raw material orientation (mono-specialization), which at the same time determine all economic and social processes taking place in the city [2]. The Program for monocities development is Kazakhstan identifies several major risks, proposes target indicators and development directions.

Risks for monocities identified by the governmental analysis:

- **Economic:** closure of city-forming enterprise, low level of economy diversification, high dependence of the city population on city forming enterprise, high dependence of city budget on taxes coming from forming enterprise.
- **Social:** high unemployment rate, low level of income and low life level in general, decrease of residents' number, possible trends in social tension growing.
- **Infrastructure:** high degree of wear of engineering and social infrastructure, high environmental pressure on the territory, significant exposure of territories to natural and man-made emergencies.

Target indicators of the Program for 2015:

- To increase the volume of industrial production of single-industry towns with low economic potential as a result of the implementation of one or more "anchor" investment projects - by at least 20% (compared to 2011).
- To increase the number of actively operating small enterprises in single-industry towns - 2 times (in comparison with 2011).
- To reduce the proportion of the population with incomes below the subsistence level in single-industry towns - to a level of no more than 6%.
- To reduce the unemployment rate in single-industry towns - to a level of no more than 5.5%.

Target indicators of the Program for 2020:

- To increase the number of actively operating small enterprises in single-industry towns - by 4 times (in comparison with 2011).
- To reduce the share of the population with incomes below the subsistence minimum in single-industry towns - to a level of no more than 6% (considering the improvement of the Methodology for determining the subsistence minimum in 2015).
- To reduce the unemployment rate in single-industry towns - to a level of no more than 5%.

Development directions:

- Optimization of single-industry towns depending on the production capacity of stably operating enterprises (Identification of the economic potential and new promising specializations of single-industry towns.)
- Diversification of the economy and development of small and medium-sized businesses to ensure the optimal structure of employment for the population of single-industry towns.
- Increasing the mobility of the labor resources of single-industry towns, stimulating voluntary relocation to settlements with a high potential for socio-economic development and centers of economic growth.
- Development of social and engineering infrastructure of single-industry towns based on the optimal population size.

Financing of the Program will be carried out at the expense and within the funds of the republican and local budgets, as well as other sources not prohibited by the legislation of the Republic of Kazakhstan. The volume of financing of single-industry towns in the pilot year 2012 at the expense of the republican budget will amount to 6,000.0 million tenge to solve priority problems. Approximately from the republican budget: for 2013 – KTZ 38,200 Million, 2014 – KTZ 43,200 Million 2015 – KTZ 53,900 Million.

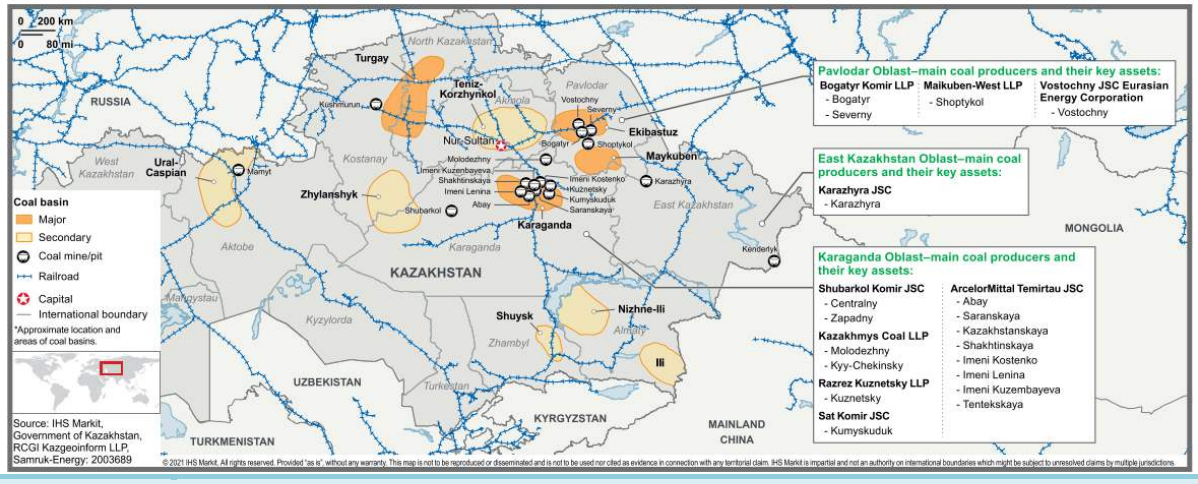
1. Economics of coal production

1.1. Coal production and use in Kazakhstan

Kazakhstan is a rich country in coal and gas reserves.

Kazakhstan cumulates 29.4 billion tons of the equivalent of proven and probable coal reserves which represents 2.4% of the world total reserve [3]. The largest coal basins are located in the central and northern parts of the country: Ekibastuz, Karaganda, and Turgay (**Figure 1**) [3]. Most coal has high moisture content, relatively low heating values and high ash and sulfur content meaning that its combustion is associated with substantial emissions of particulate matter and sulfur dioxide [3].

Figure 1. Kazakhstan's coal basins and key production sites [3].



Key message Coal reserves are mainly concentrated in Pavlodar region (Ekibastuz basin with 10 billion tonnes) and Karaganda region (Karaganda basin with 6.9 billion tonnes).

Kazakhstan's coal reserves are mined and processed by 25 private company, four of them generate three third of the annual production [1]. In 2020, annual production was 109.2 million tonnes of coal and lignite from which 80% were consumed in domestic market and 20% was exported [3]. Exports to Russia represents 86% of the total coal export in Kazakhstan, in 2020 20 million tonnes was exported to Russia, the rest was mostly bought by Europe and China [1].

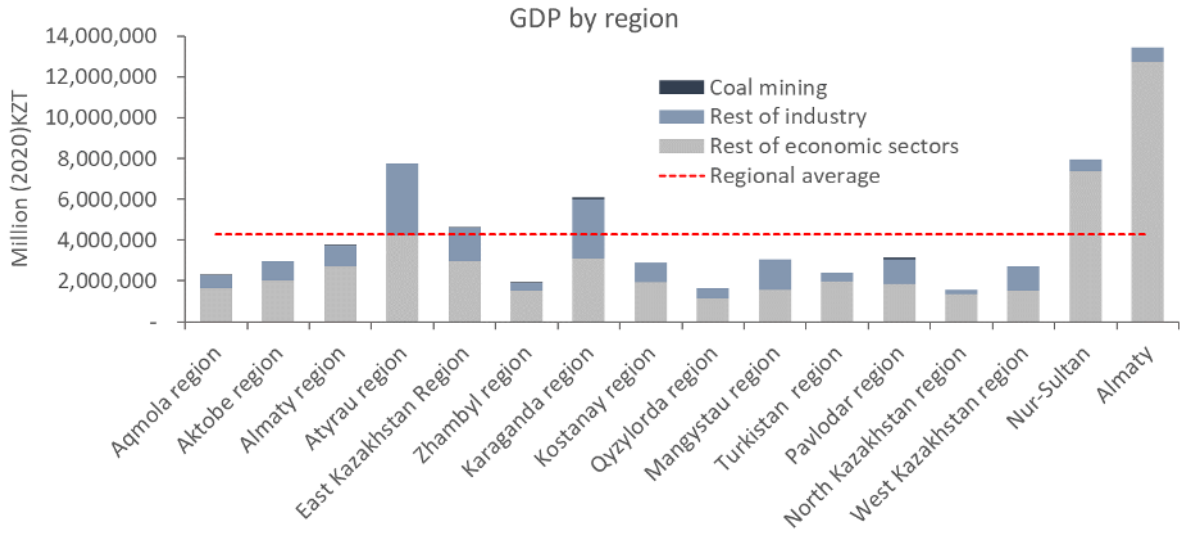
In total, coal accounts for around 50% of domestic energy supply in Kazakhstan. It is responsible for over 70% of country electric power and heat generation. Coal covers about 20% of energy demand by industry, residential and tertial sector. It also supplies about 15% of agriculture energy needs.

GDP contribution

Industry added value to the regional Global Domestic Product (GDP) is important and represents in average around 30%. In coal-based regions industry share in the total GDP is more important. In Karaganda region it increases up to 50%, in Pavlodar region – up to 41% (**Figure 2**). The added value of coal mining in the total regional GDP varies from less than 0.01% (for Aqmola region) up to 2.5% (for Pavlodar region). Such small share of coal mining in GDP suggests that the direct impact of coal mines

closure be moderate on regional economies. However, it is important to account for the impact from the transition of industries using coal. Power and heat generation, heavy industries, metallurgy (iron and steel) will be the most affected by the transition form coal. Moreover, impact will be very pronounced in monotowns.

Figure 2. GDP by region.



Key message	Industry contribution represents in average 30% of regional GDP; industry added value is particularly important in coal regions, such as Karaganda (50%) and Pavlodar (41%) regions.

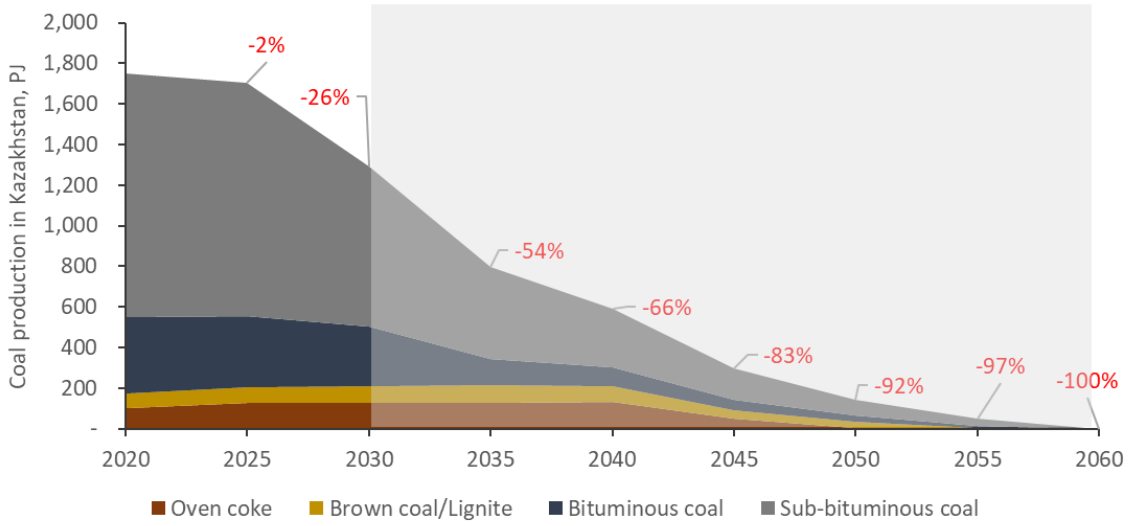
Emissions intensity of country economy could erode the competitiveness of industries. Demand for goods produced using fossil fuel-intensive energy are likely to face increasing barriers as global climate policies, such as the implementation of EU's Carbon Border Adjustment Mechanism (CBAM). This policy mechanism will increase import duties for goods from emission-intensive countries targeting first product categories presenting the most risk for carbon leakage, such as cement, iron and steel, aluminum, fertilizers, electricity, and hydrogen [4]. From 1st October 2023 CBAM will operate in a transition phase before the permanent mechanism will enter into force on 1st January 2026. The price of the CBAM certificates will be linked to the weekly average carbon price in the EU ETS that by 2025 is expected to reach USD 114 per tonne of CO_2 eq [5]. While its impact on coal exports from Kazakhstan will be minor (with moderate coal volumes exported from Kazakhstan to EU), it may significantly impact the rest of country industry relying on coal.

According to the United Nations COMTRADE database, in 2022 European Union imported from Kazakhstan iron and steel of USD 503.3 Million, aluminum of USD 263.2 Million and fertilizers of USD 34.26 Million. Our estimations suggest that if these exports are maintained, Kazakhstan could lose over USD 250 Million in export receipt in 2024 and, under increasing EU carbon price, over USD 400 Million in 2025. This estimations confirm the projections of the World Bank Group conclusions [6].

1.2. Coal production under the Carbon Neutrality Strategy

According to the Carbon Neutrality Strategy, the total coal production in Kazakhstan will need to drop by 26% by 2030 in comparison with the current level. This drop is mainly related to the decrease in sub-bituminous coal extraction, the production of other types of coal remains relatively stable in this decade. The most spectacular drop occurs after 2030 when the total coal extraction is supposed to be cut in half already by 2035, 90% of reduction must be achieved already by 2050. The coal export is expected to start to decrease after 2030.

Figure 3. Coal production under the Carbon Neutrality Strategy.



Key message	The strategy suggests an important drop in coal extraction – by 2035 the total production supposes to be cut in half.

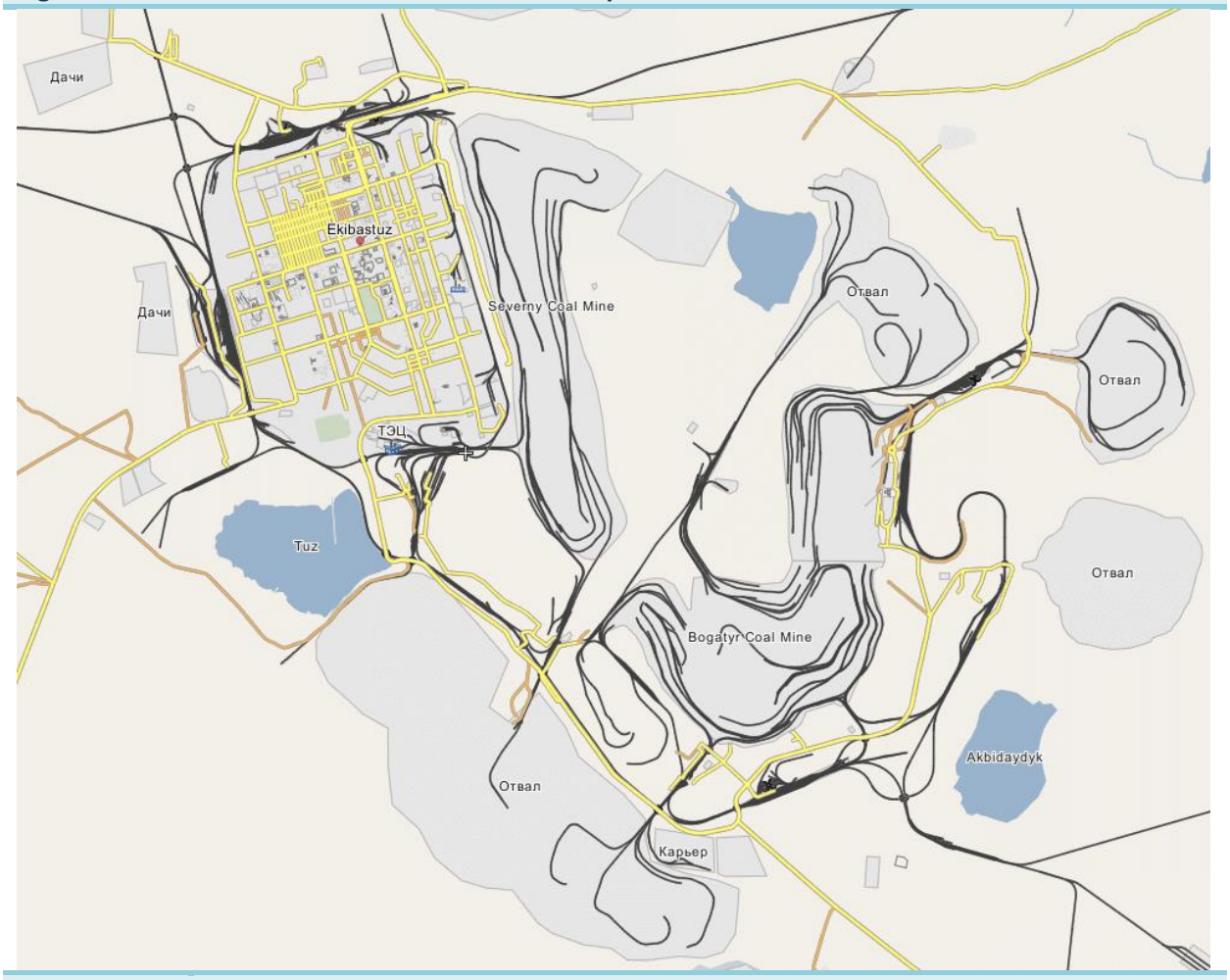
The decrease of coal production will affect all coal production sites situated mostly in Karaganda and Pavlodar regions.

1.3. Decrease of coal mining in Ekibastuz

Deposits in the Ekibastuz Basin in particular stand out in terms of the low cost at which they can be produced; the seams are thick and located near the surface, making them easy to work using regular surface mining methods [3]. There are two big coal mines in Ekibastuz (**Figure 4**):

- **Severny mine** (open pit) is the oldest mine in Ekibastuz coalfield situated at the Eastern border of the city. Its annual production capacity is 10 million tonnes.
- **Bogatyr mine** is one of the largest open pit coal mines in the world. with the total annual production capacity of 32 million tonnes.
- **Vostochny mine** is situated in the middle of Ekibastuz coal basin (Northern from the Bogatyr mine) It produces around 18 million tonnes annually.

Figure 4. Coal mines in Ekibastuz. Source: Wikimapia.



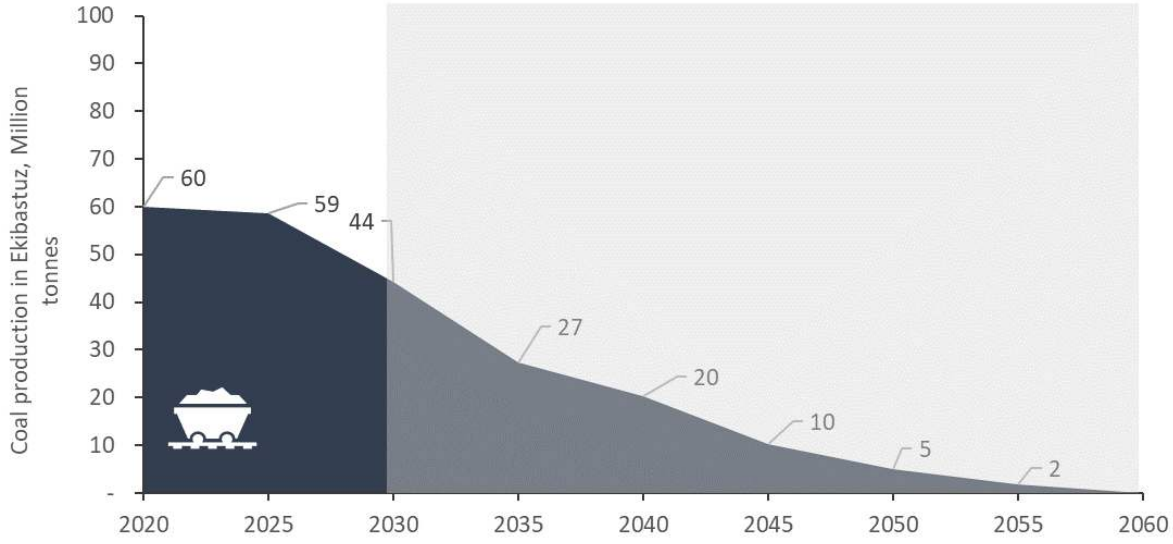
Key message Ekibastuz hosts largest open-cast mines in the world.

Coal mines supply Ekibastuz power plants. Bogatyr mine is located 35 km from GRES-1[1] and 53 km from GRES-2 (distance by rail).

Since Ekibastuz mines produce more than half of coal in Kazakhstan, they may be directly affected by the Carbon Neutrality Strategy. The coal mining in Ekibastuz will need to drop from the cumulative 60 Million tonnes per year in 2020 to 44 Million tonnes in 2030. This represents 26% decrease of coal production.

[1] GRES (Russian: ГРЭС - Государственная Районная Электростанция) means State Regional Power Station.

Figure 5. Coal mining in Ekibastuz following the Carbon Neutrality Strategy.



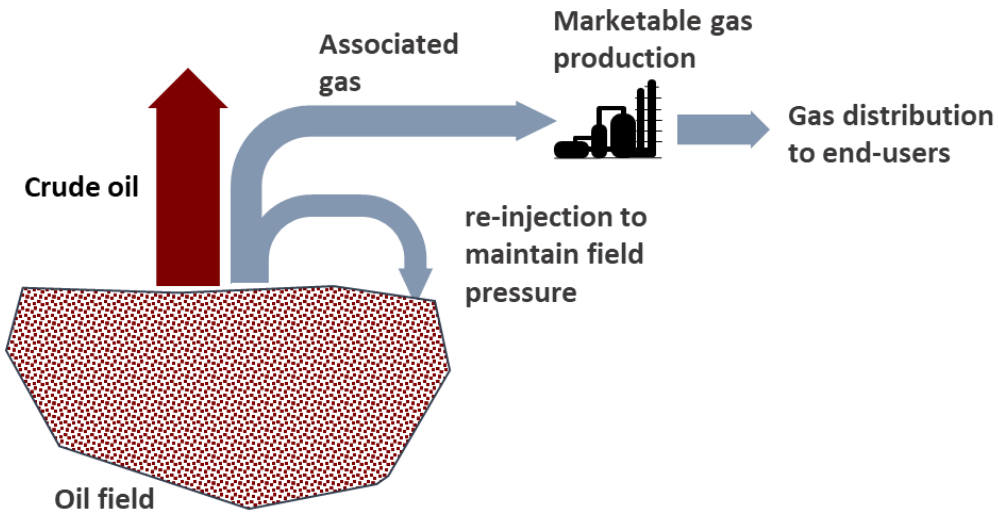
Key message	The strategy suggests an important drop in coal extraction – by 2035 the total production supposes to be cut in half.

2. Gas production, energy tariffs and affordability

2.1. Natural gas production and use in Kazakhstan

Kazakhstan accounts for eight major gas basins with total reserves for recoverable gas estimated to 4,432,602 Million m^3 [3]. The extraction of natural gas is continuously increasing. In 2020 it reached 55.1 Billion m^3 with 91% coming from the three top gas producers [3]. More than 70% of the gas they produces is associated gas, i.e., the by-product of oil production, which portion is reinjected back into oil reservoir to maintain field pressure (**Figure 6**). The national operator QazaqGaz (KTG) which main activity is the operation of Kazakhstan's national gas grid is responsible for less than 1% of country's gas production in 2020 [7].

Figure 6. Interdependence of oil and gas production.



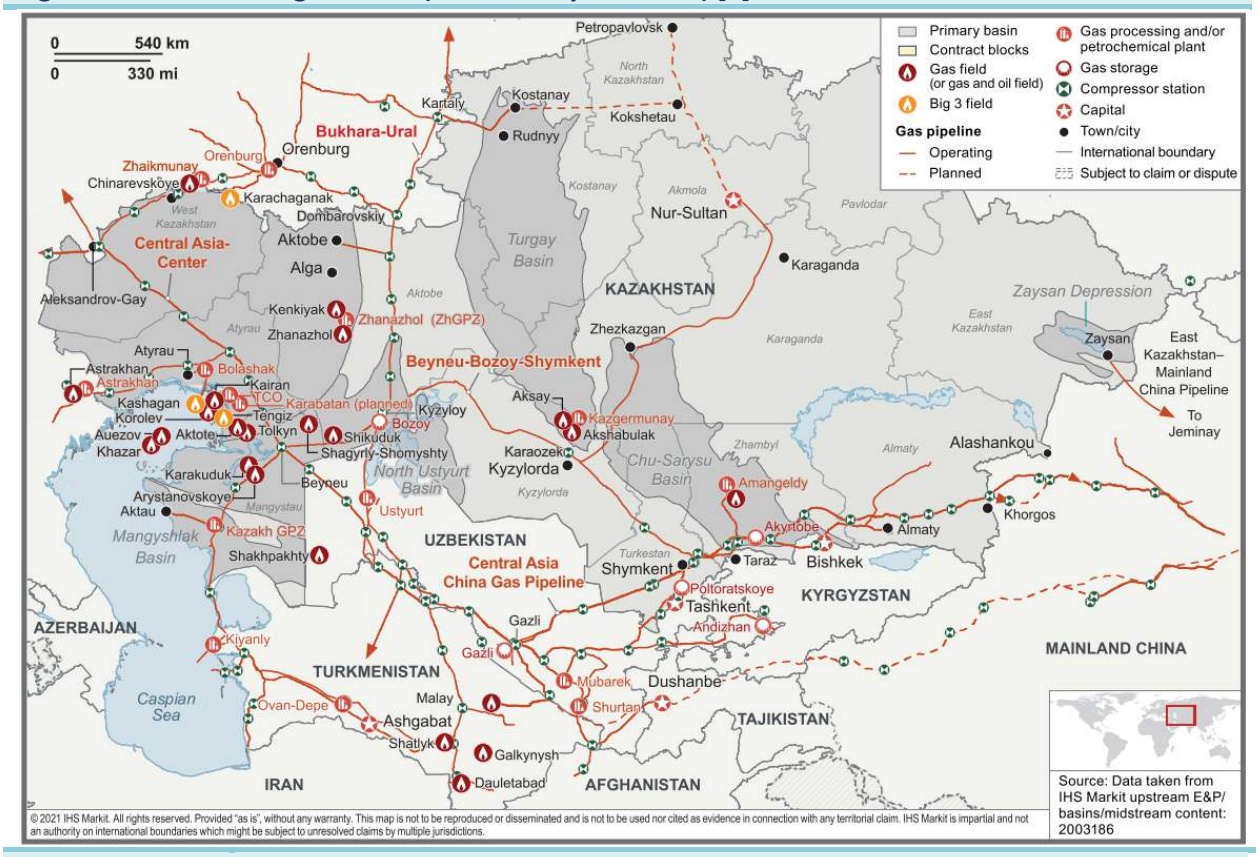
Key message	Quantity of associated gas production depends on quantity of extracted oil. To maintain or increase oil extraction (and consequently gas extraction), a portion of gas needs to be re-injected in oil reservoir.

In 2020, Kazakhstan produced a net 29.9 Billion m^3 of marketable natural gas. Kazakhstan exported 19.8 Billion $m^3$to China, Switzerland, Ukraine, and other countries, and imported 12.4 Billion $m^3$of natural gas, resulting in 7.4 Billion $m^3$of net export in 2020 [1]. Kazakhstan's gas import/export infrastructure is being supported by 6 different pipelines (**Figure 7**). With a 60 Billion m^3/year capacity, China-Central Asia Gas Pipeline is the biggest pipeline carrying gas from Turkmenistan, the western part of Kazakhstan to the Xinjiang region in China [8].

In 2020, Kazakhstan consumed 17.1[2] Billion $m^3$of gas in various sectors, most demanding sector is the electricity-heat production sector (42.1%) followed by residential (16.2%), and the remaining sectors are other energy, industry, transportation, and services. Gasification levels in Kazakhstan vary from more than 99% in Atyrau and Mangystau regions to zero for regions, such as North Kazakhstan, Pavlodar and Aqmola.

[2] Reported as end-of-pipe deliveries by the Ministry of Energy.

Figure 7. Kazakhstan's gas sector (selected key elements) [4].

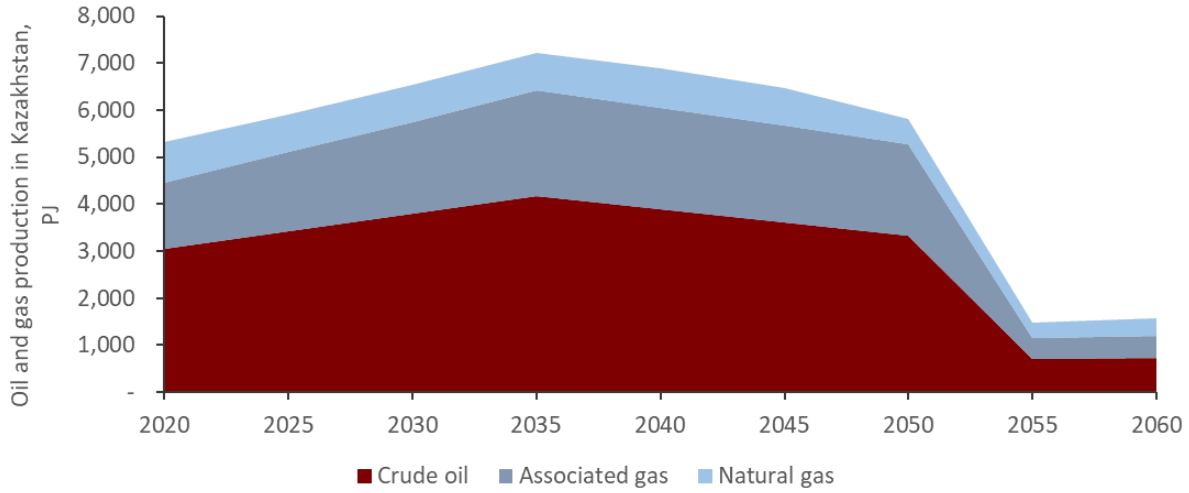


Key message Gas production is concentrated in Western Kazakhstan. Western regions have the highest gasification level, with natural gas being used in power generation, industry, commercial and residential sectors.

2.2. Increase of gas production and coal-to-gas switch

The coal phase-out will require an extended country gasification leading to the increase in natural gas use. To address domestic market demand, exports to other countries must be reduced or even stopped. Because of the strong regulation enforcing national gas prices, marketable gas production and transport in Kazakhstan are under the risk of being non-profitable. With the decrease in exports, QazaqGaz will be no longer able to counterbalance financial losses from domestic sales with revenues from exports (that is rewarded with much higher gas prices than domestic). Our calculations confirm that QazaqGaz may encounter losses exceeding 1,000[3] billion tenge between 2022 and 2026 from domestic sales. With the decreasing share of natural gas exports, it is not clear if the main operator will be able fully recover these losses.

Figure 8. Natural gas production in Kazakhstan.



Key message Natural gas production in Kazakhstan is highly dependent of oil extraction.

This conclusion is confirmed by some national experts, notably in the recent interview [9], that go further by highlighting a potential risk for gas shortage in Kazakhstan. This risk is amplified not only by the absence of financial incentive for producers to generate marketable gas for domestic use, but also by the fact that "the (oil) fields have already passed the peak of their production and are at a late stage of operation" requiring each year "even larger volume to inject into reservoirs, maintain or stabilize the production of liquid hydrocarbons." The expert expresses the opinion that Kazakhstan natural gas prices should be three times higher than the current level, because infrastructure and gas transportation are very expensive, and usually tied to dollar (equipment, materials, licenses are imported and denominated in foreign currency)."

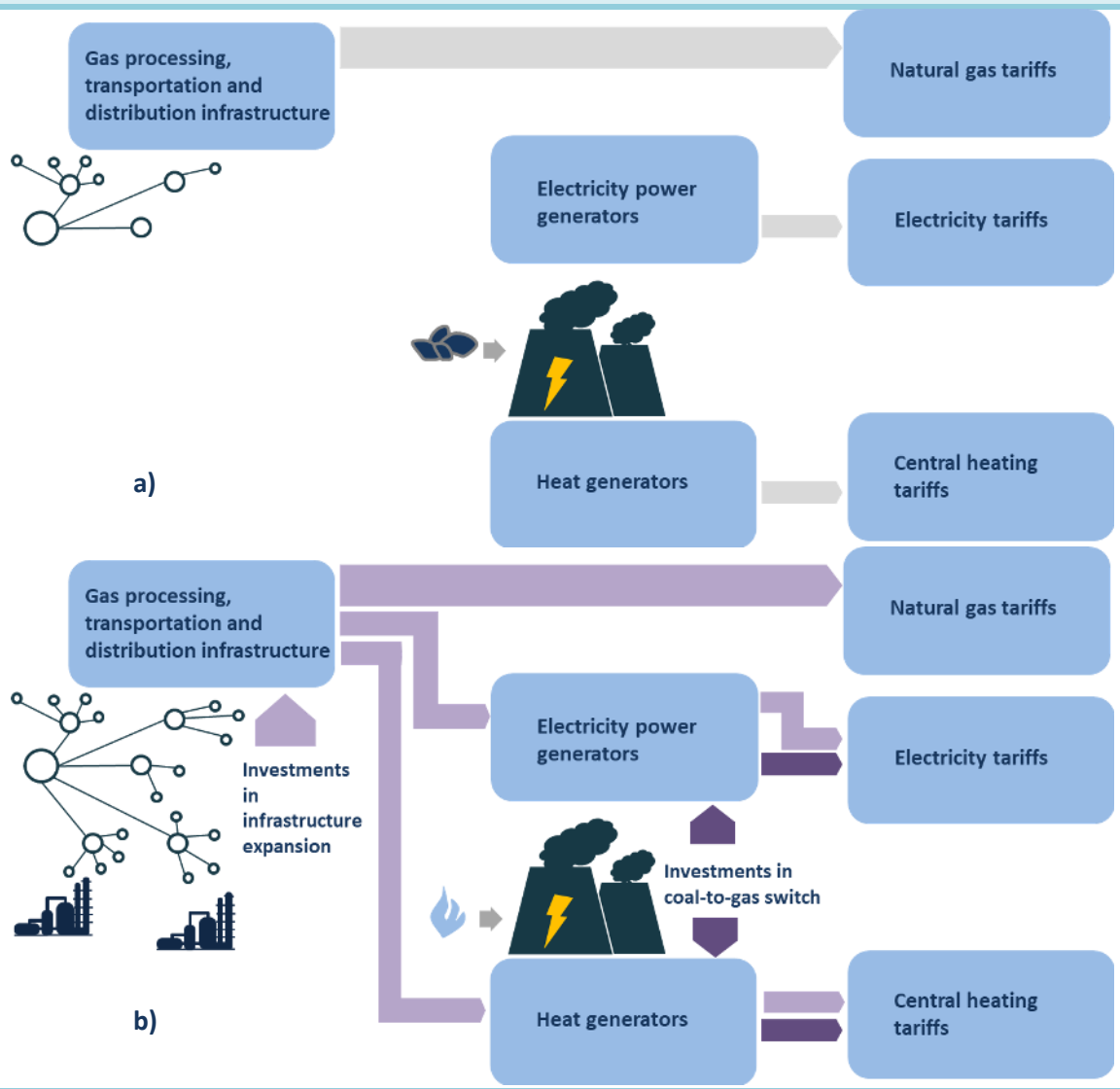
To ensure coal substitution natural gas and oil production observes more than 20% increase between now and 2030 (**Figure 8**). According to the official projections Kazakhstan will continue to increase its natural gas production that much reach almost 90 Billion m^3 in 2030 [10]. At the same time volumes of natural gas that will be re-injected into oil reservoirs to maintain pressure suppose to increase as well. 20.5 Billion

[3] Financial losses of QazaqGaz announced in Министерство юстиции Республики Казахстан, "Об утверждении Комплексного плана развития газовой отрасли Республики Казахстан на 2022 – 2026 годы," Постановление Правительства Республик Казахстан от 18 июля 2022 года № 488, 2022. [Online]. Available: https://adilet.zan.kz/rus/docs/P2200000488. [Accessed: 03-Oct-2022].

m^3 (36% of all gas produced in Kazakhstan) was re-injected in 2022, in the period 2025-2050 the re-injection may reach 82 Billion m^3 annually (almost 50% of total gas production). This means that in 2030 only half of all produced gas will be available for transformation into marketable gas.

Under energy transition end-use consumers must not only support the expenses of the existing energy systems, but also additional investments for gas infrastructure expansion, coal-to-gas generator conversion, cost of natural gas to power these generators. The increase in the end-use consumption and consumers number not always allow to mitigate the important increase in the retail tariffs. To keep up with various expenses, it was found that end-use energy tariffs must increase as fast as they could respecting regulation caps. Unfortunately, even this increase may not allow to recover all costs. It was found that non-regulated retail residential tariffs for natural gas must be already now at least two times higher, electricity tariffs must be at least 13% higher.

Figure 9. System costs that are passed to energy tariffs in a) actual energy supply chain and in b) supply chain with gas infrastructure expansion and power/heat coal-to-gas switch.



Key message	The expansion of natural gas infrastructure and coal-to-gas switch may substantially impact all energy tariffs in case if tariff regulation is relaxed.

This rases a fair question:

Will government relax regulation to make gas tariffs closer to their market level to decrease operator losses and provide incentives for producers?

Energy prices may substantially increase to support country gasification under Carbon Neutrality Strategy. Another option will be to maintain strong regulation (especially in regard to the natural gas tariffs) and to offer various subsidies to national gas operator, regional distribution company, power and heat generation companies. Since it is not clear what pathway will be selected, support measures for households in Ekibastuz were evaluated for these two opposite options:

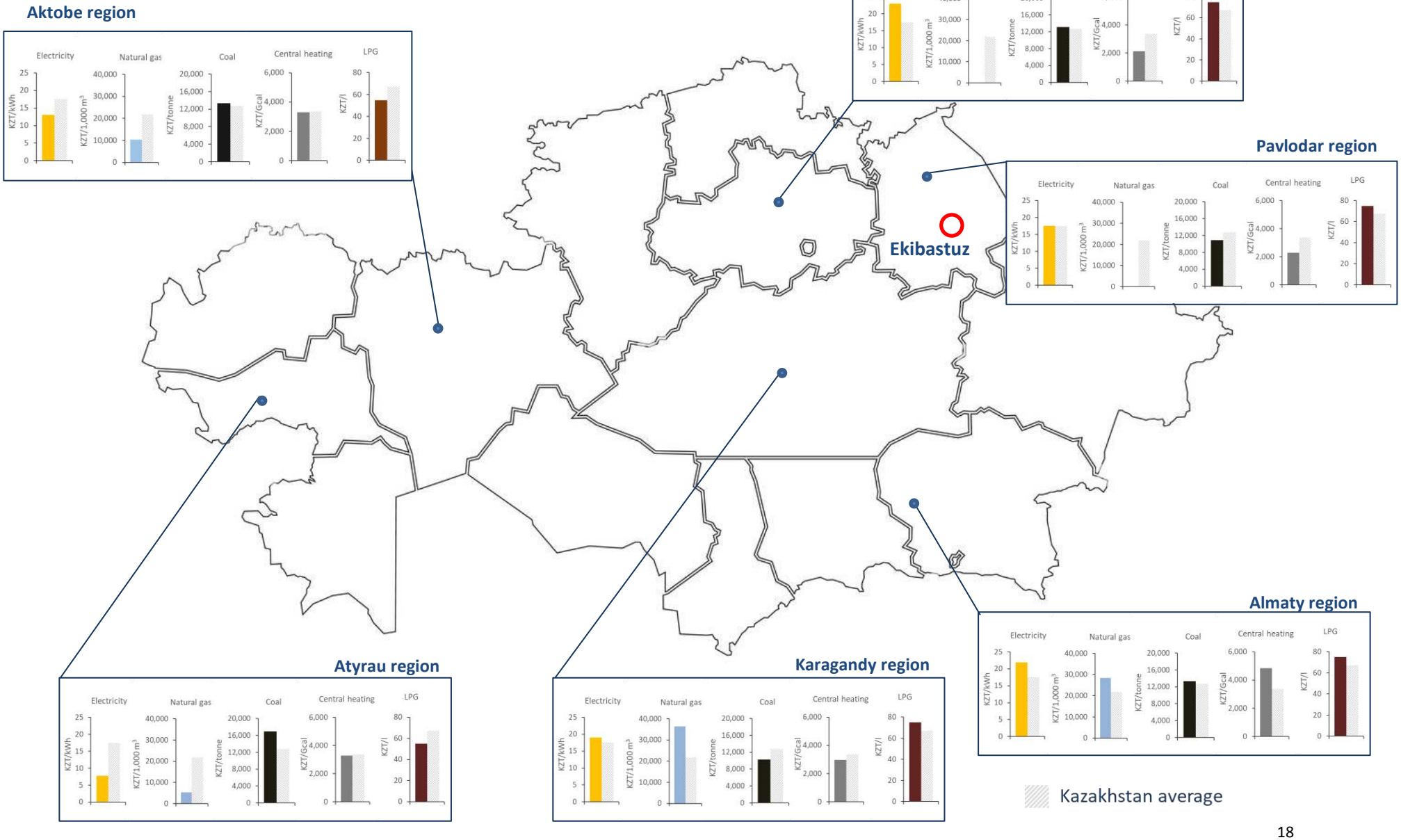
- **Scenario 1. Gasification is done under current regulation**, i.e., energy tariffs continue to increase in respect of current regulation in place in Kazakhstan.
- **Scenario 2. Gasification is done under non-regulated prices**, i.e., energy regulation is relaxed and energy tariffs start to increase to reach their market value.

EQUITY AND TARIFFS FAIRNESS

Tariffs in Kazakhstan are highly dependent on the region and are very disperse creating the following bottlenecks:

- **Households using different fuels to satisfy the same end-use in different regions pay different bills.** For instance, two equivalent households situated in Ekibastuz and Oral, both relying on autonomous system or individual furnace for space and water heating, have substantially different energy expenses. A household in Ekibastuz uses coal for space heating, while a household in Oral relies for these on natural gas. Required heat to satisfy heating demand is slightly less for household in Oral with more warmer temperatures over a year. By applying the regional residential tariffs effective in these regions, it was found that for the same end-use a household in Ekibastuz must pay almost 80,000 tenge per year. A household in Oral in average must pay less than 40,000 tenge per year to heat a home.
- **Households living in the same community pay drastically different bills for the same end-use.** Two households in Ekibastuz, one relying on individual heating system using coal, and another one on central heating, will also spend substantially different amounts on energy. Living in multi-apartment building appears to be more advantageous from the point of view of energy expenses. A household in apartment pays in average almost two times less for space heating (i.e., around 43,000 tenge per year). This is due to the fact that the central heating prices are low and do not fully reflect all costs. As a countereffect, the utility can not recover enough costs to maintain properly central heating network, that lead to failures and supply interruption.

2.3. What were residential energy tariffs in Kazakhstan in 2020?



What is energy poverty in Kazakhstan?

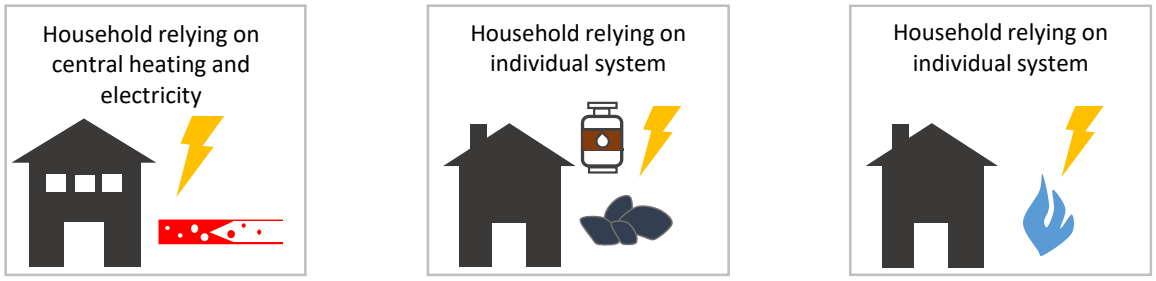
Energy burden is defined as the percentage of household income spent on energy (electricity, natural gas, coal, central heating etc.). Typically, households that spend roughly twice that the national median level have high home energy cost burdens, and are said to be experiencing energy poverty [11]. Median household energy burden in Kazakhstan fluctuates around 5% [12], placing all households spending more than 10% in the energy poverty category.

What are typical residential energy users in Kazakhstan?

For better understanding how energy poverty affects Kazakhstan population, three major types of households are defined (**Figure 10**). All three types use electricity for lighting and to power different home appliances, but they rely different types of space heating system:

(i) household living in multi-apartment building (mainly in urban area) and connected to the central heating grid;
(ii) household relying on autonomous heating system and furnace using coal as the main heating fuel (such household usually uses LPG for other purposes, such as cooking);
(iii) household relying on autonomous heating system and furnace using natural gas via gas distribution system.

Figure 10. Typical energy users in residential sector in Kazakhstan.



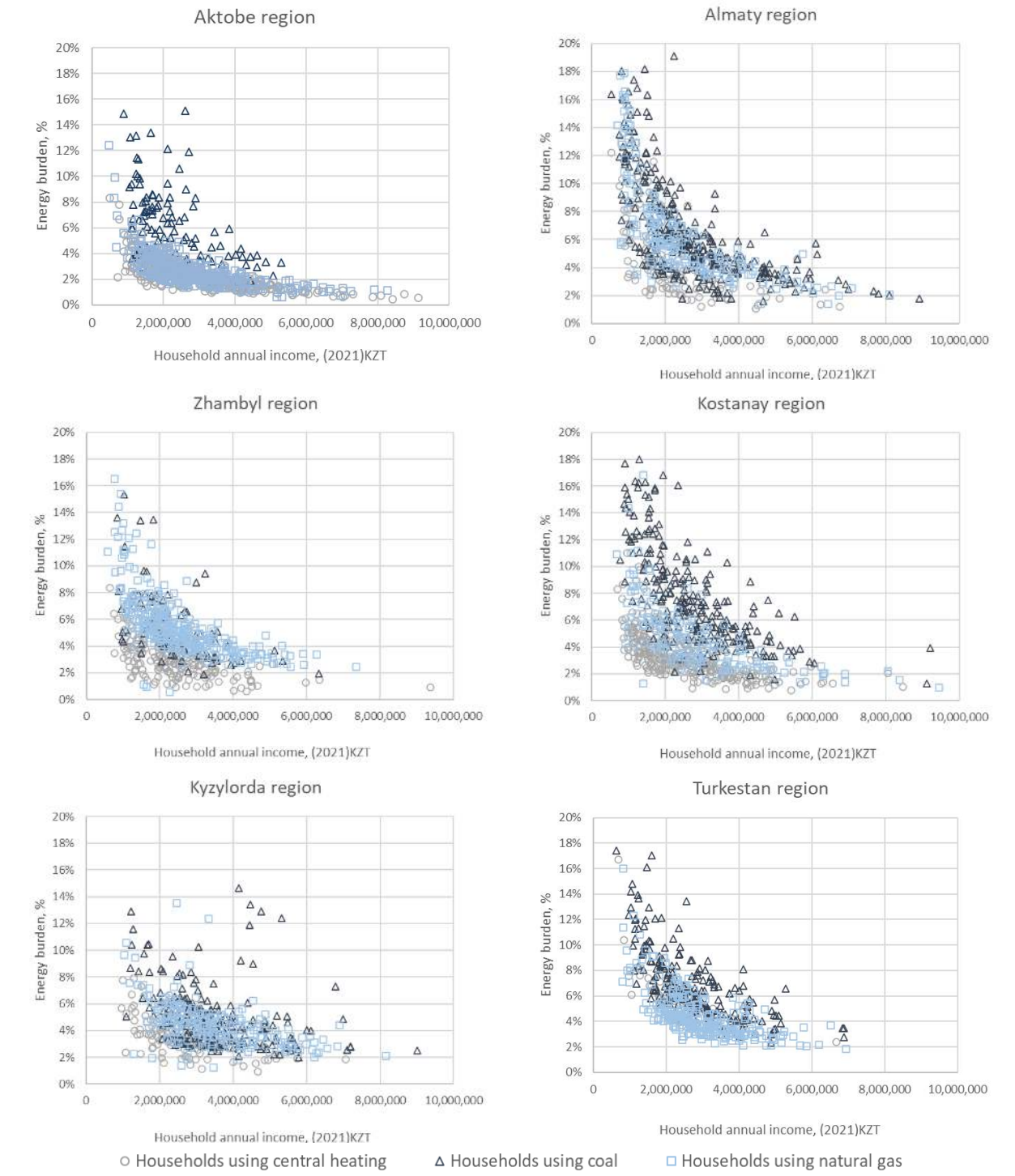
Key message According to the National Bureau of Statistics of Kazakhstan these households represent up to 98% of urban households and up to 71% of rural households in different Kazakhstan regions.

Who pays the most?

The analysis of households' energy expenses and income level (**Figure 11**) reveals the following trends:

- **Households relying on coal pays highest bills in all regions.** Households replying on central heating pay less than others. These households are followed by families relying on natural gas. In regions with cheaper gas, such as Atyrau and Aktobe, energy expenses for gas and central heating may be very similar. The most expensive energy bill is paid for households relying on coal. In some regions, LPG used for cooking may contribute to the high expensive of households relying on coal.
- **Households relying on coal are most exposed already now to their energy bill increase.** Central heating and natural gas tariffs are more regulated and almost do not vary withing the same region. On the opposite, tariffs for coal are less regulated and may considerably vary within each region depending on household location, coal transportation mode, distributors margins, coal grade.

Figure 11. Distribution of energy burden in regions with access to both natural gas and coal[4].



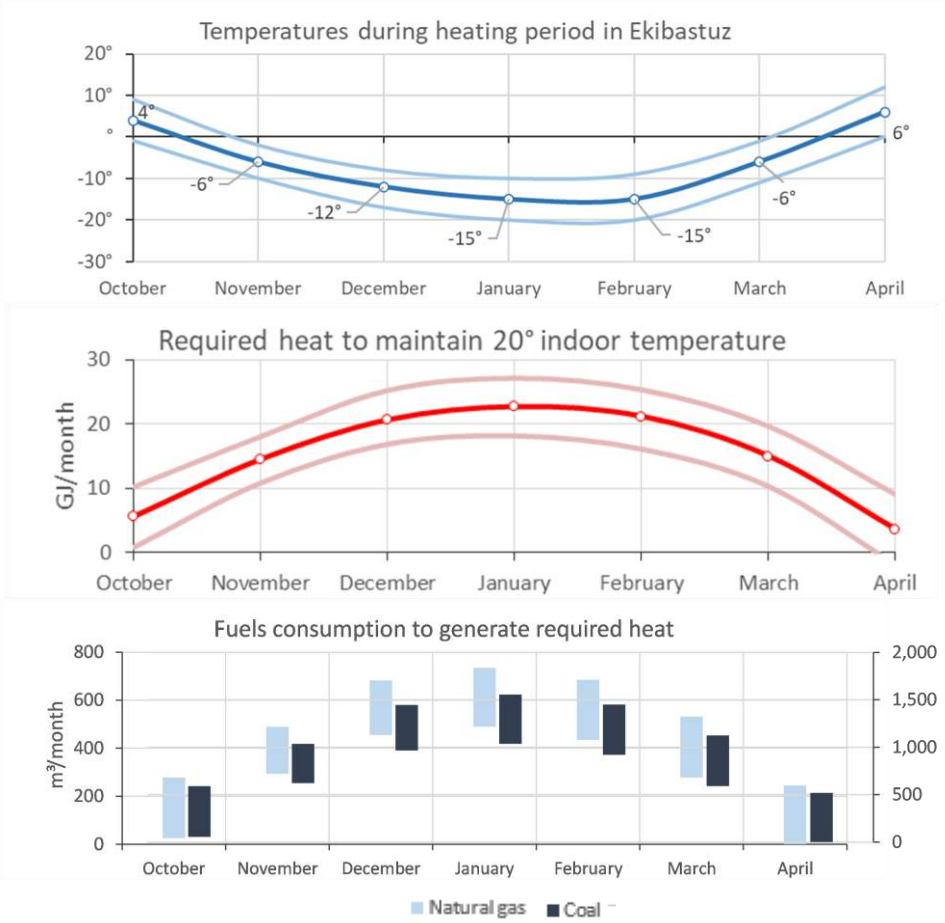
Key message	Coal is the most expensive energy for households. Households relying on central heating, followed by households relying on natural gas, usually pay less.

[4] Households using natural gas only for cooking or water heating are excluded. Source of data: National Bureau of Statistics, Energy expenses survey, 2021.

ENERGY REQUIREMENTS FOR A HOUSEHOLD HEATING IN EKIBASTUZ

Quantity of fuel required to heat home depends on the outside temperatures and inside comfort temperature, quality of building envelop, calorific value of fuel and efficiency of heating installation. The heating season lasts from October to April, with January and February as the coldest months with the average temperature of -15°C with (minimum going lower than -20°C). Heat required to maintain a comfortable inside temperature each month is estimated for a home of an average surface of 70 $m^{2(1)}$ with the low- efficiency building envelop. During the coldest months it will require to generate heat equivalent to more than 20 GJ monthly. Efficiencies of individual heating systems using coal and gas are 70% and 95%, respectively. A calorific value of coal is within the range 25-35 MJ/kg and A calorific value of marketable natural gas is around 39 MJ/m^3. Consequently, an average consumption of coal for an entire heating season for an average Ekibastuz household using individual heating system is 5.9 tonnes/year. In case of coal-to-gas switch the consumption of natural gas is estimated to be around 2,800 m^3/year.

This is consistent with the National Bureau of Statistics, in 2021 that recorded **6.4 tonnes/year** as an average consumption of coal by households with individual heating system. This consumption is taken as the average for this report analysis. After coal-to-gas switch the average consumption of gas will be **3,400 m^3/year**. Natural gas will be not only used for heating but will also replace gas in bottles (LPG) currently used in individual households for cooking.



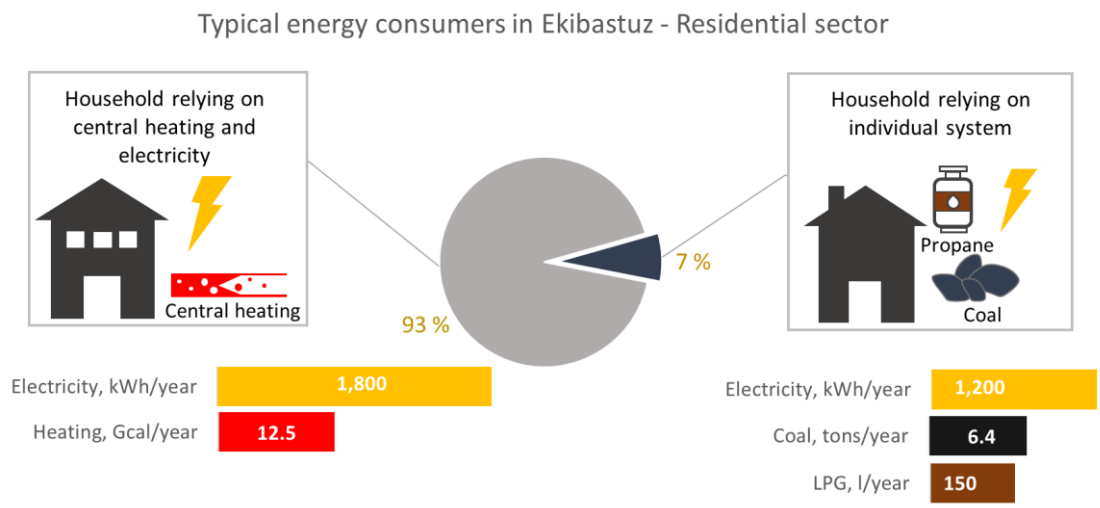
(1) Average surface of individual home recorded for Pavlodar region by the National Bureau of Statistics.

2.4. Energy affordability for Ekibastuz residents

According to our estimations supported by the Energy Use Survey of the National Bureau of Statistics of Kazakhstan [13] the residential sector in Ekibastuz is composed of:

- **93% or about 34,440 households relying on central heating**
- **7% of about 2,770 households with individual system with coal**

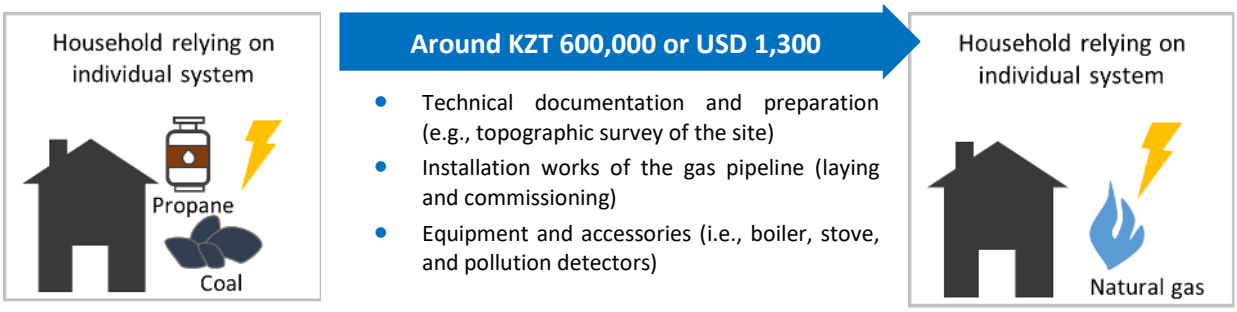
Figure 12. Typical energy users in residential sector in Ekibastuz.



Key message	Households, living in multi-apartment buildings, use central system for heating and electricity for cooking and other appliances. Households, living in private houses, use coal-based system for heating, LPG for cooking and electricity for appliances.

Gasification will affect Ekibastuz households in different ways. Households relying on individual heating system will be facing the costs of connection to gas distribution and replacement of their system to switch from coal to gas (**Figure 13**). Households in multi-apartment buildings will be indirectly switched to gas through the coal-to-gas switch at the thermal power plant level.

Figure 13. Capital investments in coal-to-gas switch by a household living in private house.



Key message	A household living in private house must invest around 600,000 KZT to connect to the gas distribution grid and to replace its old equipment.

Coal-to-gas switch will require subsidies to support households from lower income categories to avoid energy poverty (to keep their energy burden under 10% limit):

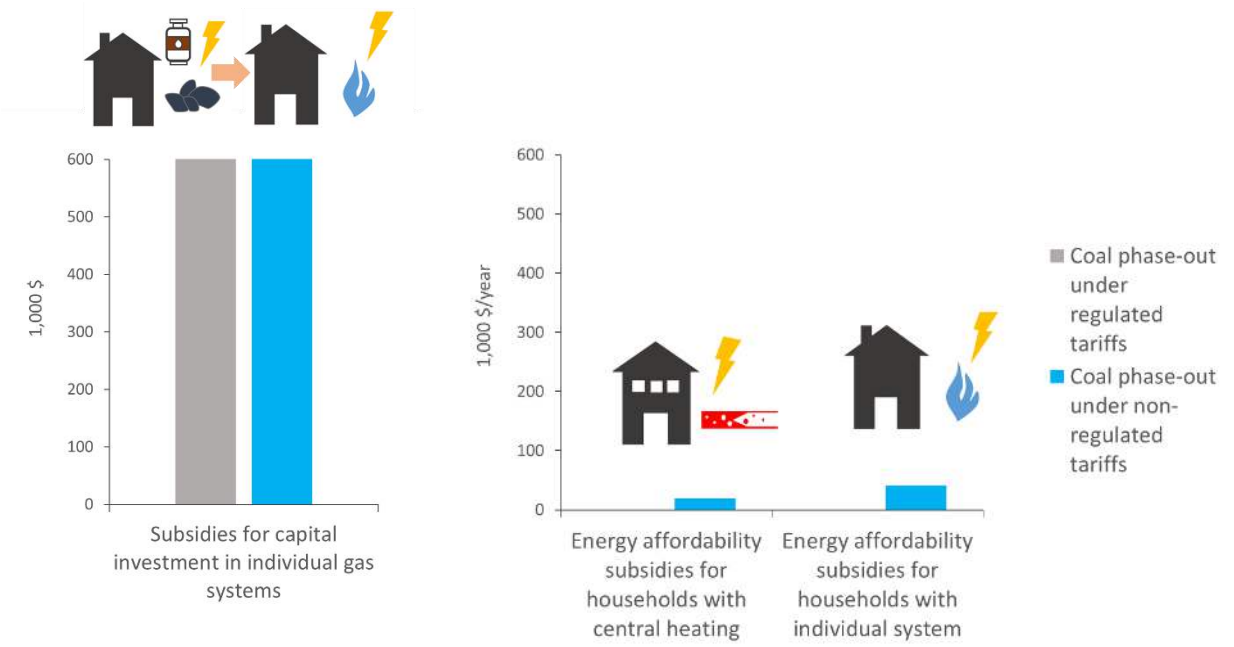
$$\textbf{Energy burden} = \frac{\textbf{Expenses for energy}}{\textbf{Income after taxes}}$$

$$\textbf{if Energy burden} > 10\%, \textbf{Household experience energy poverty}.$$

This report estimates the amount of two types of subsidies:

- Support for capital investments that households in private house must engage to connect to gas distribution and to replace of their old equipment;
- Application of direct rebates to energy bills of eligible consumers from low-income category (this will help to keep energy affordable under energy tariffs increase).

Figure 14. Energy affordability subsidies required to support households in Ekibastuz.



Key message	It will require USD 600,000 to support around 830 households to replace their equipment and to connect to gas. In case of tariffs increase additional USD 60,000 per year will be required to support low-income households for the energy affordability in Ekibastuz.

Coal-to-gas transition in residential sector in Ekibastuz will require different amounts of subsidies under different scenarios:

- **Scenario 1. Energy tariffs increase according to current regulation in place in Kazakhstan.** The increase in energy tariffs will not affect energy poverty in Ekibastuz. Moreover, households relying on individual systems will more likely pay less for heating with gas than they paid before using coal. It will require, however, to support capital investments for gas connection and equipment replacement. The total amount of subsidies under this scenario is about **USD 600,000**.

- **Scenario 2. Energy tariffs are non-regulated and increase to reach their market value.** The increase in energy tariffs will considerably affect energy poverty in Ekibastuz. In addition to capital investment subsidies, energy affordability subsidies (bills rebates) will require to support low-income households living in multi-apartment building and in private houses. The total amount of subsidies under this scenario equal to about **USD 600,000** to support technology switch in households and additional **USD 60,000 per year** for energy affordability rebates.

Appendix 1 illustrates how many households may be affected by energy poverty under two scenarios without and with subsidies in Ekibastuz. Under a careful planning for subsidies allocation households with energy burden exceeding 10% limit may be avoided.

RISK FOR COAL TARIFFS INCREASE UNDER COAL-TO-GAS TRANSITION

Additional risks for coal-to-gas transition may arise under both scenarios compromising energy affordability.

Households living in multi-apartment building will transition from coal to gas indirectly, i.e., the required modifications will be done at centralized level of thermal power plant and boiler system. In opposite, gas connection of households living in private houses is challenging (relies on individual households' decisions) and is costly for each energy bill payer (requires capital investments). In the absence of specific incentives, it is more likely that gasification of households with individual heating systems will come after a gasification of multi-apartment buildings. This may lead to a situation when under the switch of most households, coal demand from residential sector will decrease. The decrease in demand, absence of coal tariff regulation associated with the progressive closure of coal mines could push coal prices to increase for the remaining consumers. This increase will affect directly poor households for whom coal will be still unique energy option (if natural gas distribution is not yet in place).

This situation may be mitigated with better "synchronization" of coal phase-out, gasification and electrification strategies, and more careful planning of support subsidies for each specific type of energy consumers.

REGULATION, TRANSPARENCY AND SOCIAL ACCEPTANCE

Kazakhstan has a history of energy related protests. 2011 has been marked by several cases of industrial action in Mangistau region, with oil fields responding by sacking hundreds of workers. One of these actions led to the tragedy in Zhanaozen. At the core of the conflict typically lies the lack of an efficient mechanism to solve work-related tensions: the workers lack institutionalized ways to demand improvements in their situation, they are forced to refer to informal trade unions and unregulated protest actions [18]. Rising tensions due to discrepancies in working conditions, led to protest and people injuries in June 2019 at Tengiz oil field [19].

January 2022 was marked by protests in Zhanaozen, Kuryk, Akshukure, Atyrau and the most important in Aktau triggered by a dramatic increase in energy prices. LPG tariff was reviewed to increase from 60 tenge/liter to 120 tenge/liter starting form 1st January 2023 [20]. Following negotiation round protest group succeeded not just mitigate the tariff increase, but managed to negotiate its decrease to 50 tenge/liter as part of the social responsibility of the national company KazMunayGas in the Mangistau region [20].

While Ekibastuz city authority may not be directly involved in energy prices design, it is extremely important to establish and to support efficient communication among all stakeholders at the city level, but also with the regional and federal governments. More specifically it will be important to:

- Establish an efficient governance structure that will ensure transparent energy transition progress monitoring and communication with all stakeholders (this is impossible without a promotion of organizations representing and speaking for workers and end-use consumers);
- Ensure the efficient and transparent communication in relation with energy prices, increase timelines and available support mechanisms for various user groups.
- Introduce a comprehensive and coherent labor support plan and energy affordability program

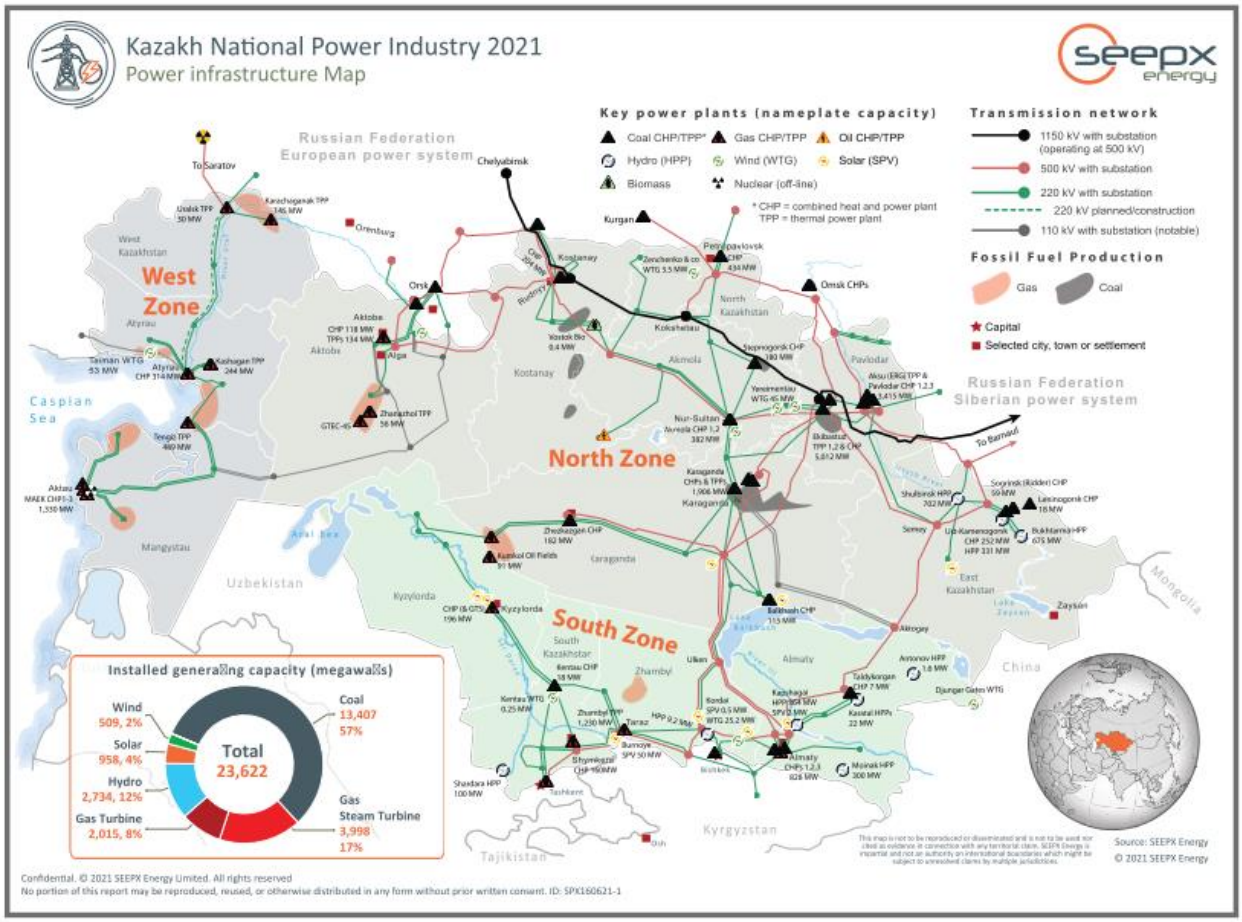
3. Coal phase-out in power and heat generation

3.1. Power and heat generation in Kazakhstan

Energy infrastructure in Kazakhstan may be divided into three zones [3]. 70% of total generation capacity of the country is located in the North Zone (with major coal and hydro power plants). Power supply in West Zone is based on gas, and South Zone being power deficient imports around 13,531 million kWh from the North Zone. However, the South Zone was leading in the development of small-size hydropower plants, and is favourable for solar and wind energy sources deployment (**Figure 15**).

The power installed capacity reached 23.6 GW in 2021 including 19.4 GW (82%) of thermal power plants out of which 13.4 GW are coal-fired and 6 GW are gas-fired [3]. Thermal power plants, large and small boiler houses provide heat transported through main and district heating networks.

Figure 15. The energy infrastructure map. Source: SEEPX Energy Ltd. Extracted from [3]**.**



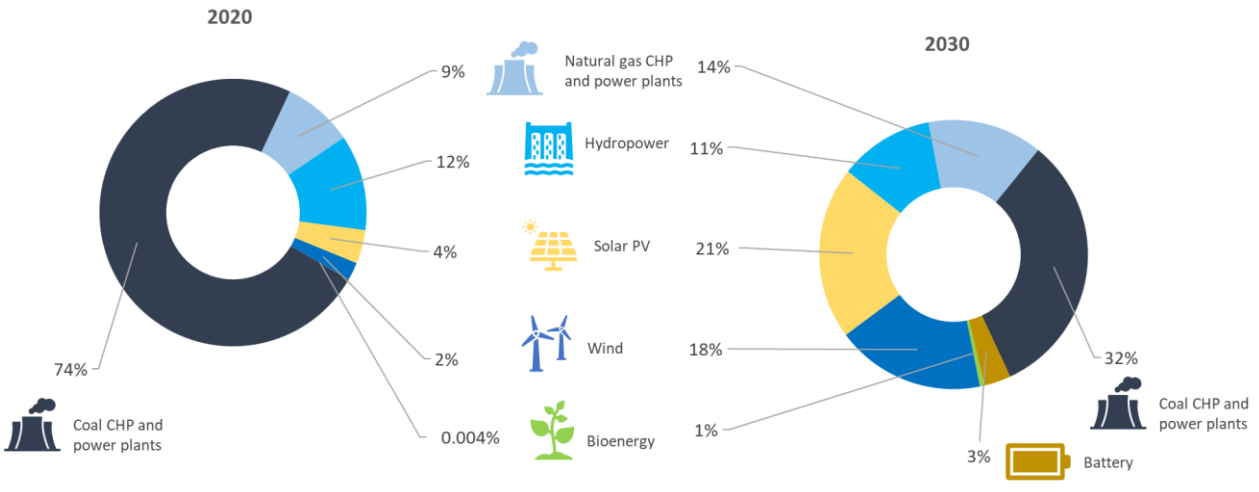
Key message	West and North Zones are energy producers relying mainly on gas and coal, respectively. South Zone is currently a net importer but holding a considerable potential for renewable generation.

3.2. Transition to gas and renewable energy

Between 2020 and 2030, following coal Carbon Neutrality Strategy, Kazakhstan power sector must progressively decrease its coal capacities while increasing gas-fired generation capacities (**Figure 16**). By the end of 2030, the strategy suggests the considerable expansion of power capacities (that almost doubles in comparison with 2025) mainly due to the deployment of renewable generators (solar PV and wind). The ambitious carbon neutrality goal drives the important electrification. Electricity generation increases by 30% between 2020 and 2030.

Historical power capacity of renewable generation (small hydro, solar, wind and biofuels) observed almost a 7-fold increase in Kazakhstan between 2016 and 2022. Solar and wind generation capacities grew considerably, in 2016 it represented 0.4% of the total power generation in Kazakhstan, in 2020 it increased up to 2.3% [14]. In 2021, annual solar and wind power generation reached 1.6 and 1.8 billion kWh, respectively. According to the Carbon Neutrality Strategy the power generation from these two sources must almost triply by 2025 in comparison with 2021 level. To keep up with decarbonization and electrification, generation together from wind and solar must be increased in 7.5 times by 2030 in comparison with 2021 level. While the 2014 adoption of an effective renewable energy legislation including on auctioning and feed-in-tariff provided a good start for the expansion of wind and solar power in Kazakhstan, it may be not sufficient to reach 2025 and, especially, 2030 targets without additional policies on renewable generation.

Figure 16. Transition of electric power installed capacity under the Carbon Neutrality Strategy.



Key message	Coal-power capacity decrease is counterbalanced by the increase in electric power generation with natural gas and renewable generators.

District heating already includes an important share of gas-fired heat generator. Under the Carbon Neutrality Strategy, the installed capacity of coal-fired heat generation is supposed to be cut in half and gas-fired heat capacity must increase by about 20%. The Carbon Neutrality requires significant efforts to improve the energy efficiency of the existing heat networks and building envelops (to decrease heat demand) and to develop of high-efficiency infrastructure in areas with dense heat demand [15].

3.3. Energy transition of centralized and distributed generation in Ekibastuz

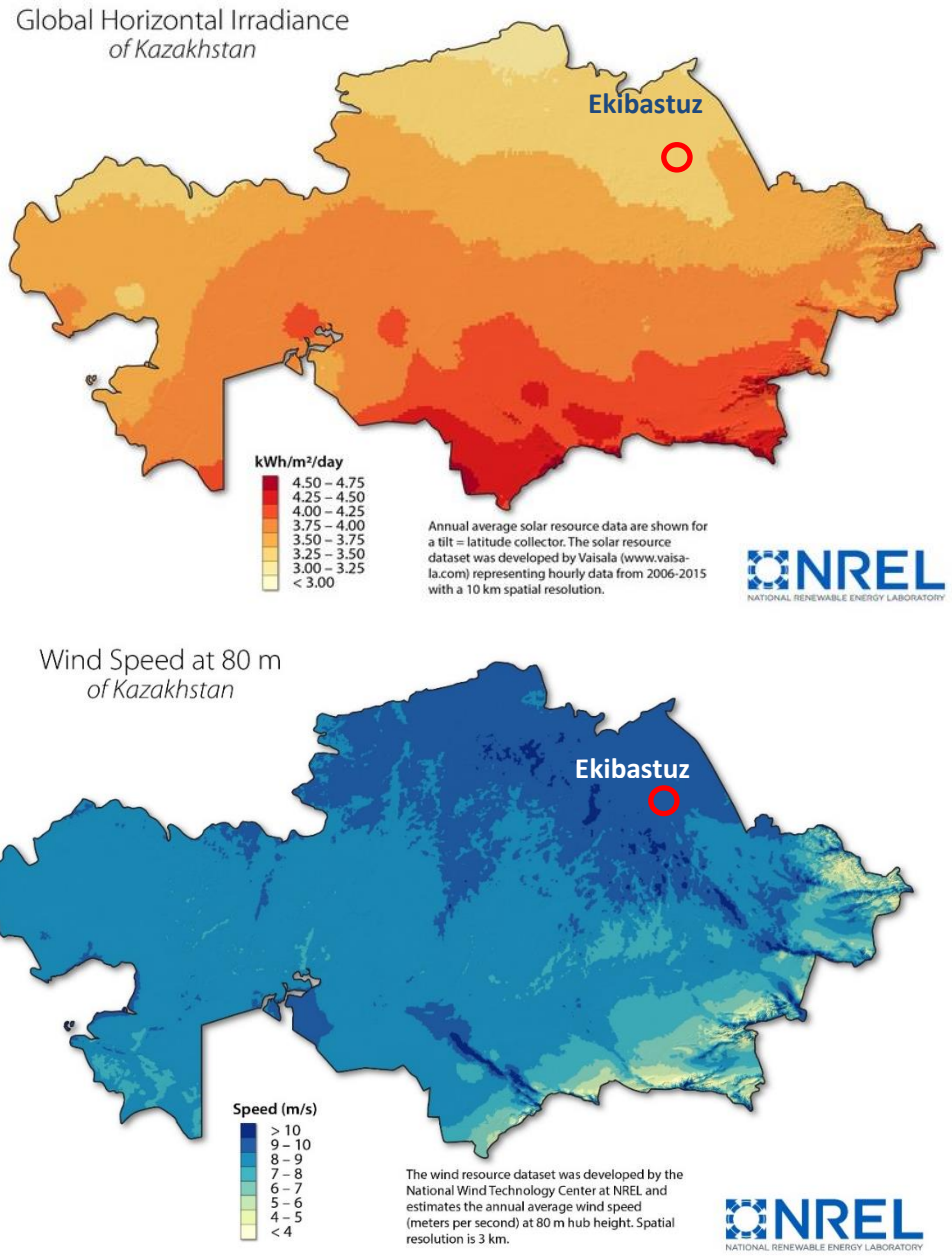
There are two big power plants near Ekibastuz. State district power plant GRES-1 is the biggest power plant in Kazakhstan, it is located 30 km away from the city. It is a thermal power plant that produces and distributes electricity, with an installed capacity of 4000 MW. GRES-2 with an installed capacity of 1000 MW is located 40 km away from the city. The main fuel of plants is coal from the Ekibastuz deposits. Heat in Ekibastuz is supplied by 12 MW combined heat and power plant situated in the city. Coal-to-gas transition at these plants will be guided by the national and regional gasification plan and will not depend on the city strategy.

The city government, local businesses and residents may play an important role in adoption of distributed renewable energy resources at the city level. While there is some variability of potential depending on the region, Ekibastuz still holds an excellent potential for deployment of wind and solar power generation (**Figure 17**):

- **Average solar irradiation is in the range 3.25 – 3.5 kWh/m^2/day.** For comparison, this same potential holds Freiburg (Germany) where most homes in Vauban district runs on solar energy generated on-site.
- **Average wind speed recorded on ground is between 15 and 20 km/h.** For comparison, it is similar to the wind potential in Eindhoven (Netherlands) and higher than in Houston (U.S.), cities that are involved in testing and adoption of rooftop wind turbines.

To be consistent with the Carbon Neutrality Strategy, the analysis estimates the potential and investments for distributed renewable generation that must address 30% of Ekibastuz demand in residential sector. Considering specificities of renewable generation deployment in urban areas, it was assumed that 28% of residential demand will be addressed by rooftop solar and the remaining 2% by wind turbines (most likely vertical axe low wind speed turbines).

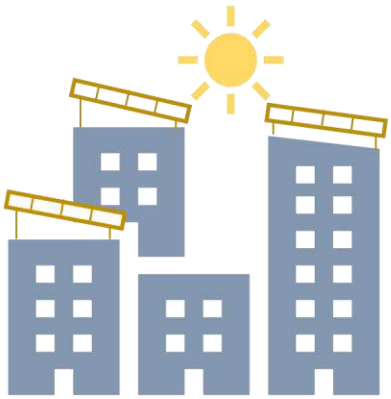
Figure 17. Kazakhstan potential in solar irradiation and wind speed. Source: NREL.



Key message	Ekibastuz holds an excellent wind and solar potential comparable with other world communities leading in adoption of distributed wind and solar technologies. Note that heat maps are used for illustrative purposes of Kazakhstan potential; potential may change depending on measurement points (e.g., height for wind speed measurements).

Example of renewable generation deployment until 2030 in Ekibastuz

PV rooftop

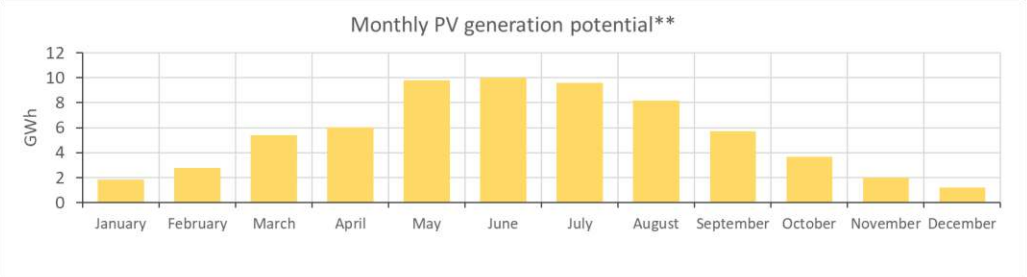


Installed capacity: 56 MW
(about 6% of total rooftop potential in Ekibastuz)

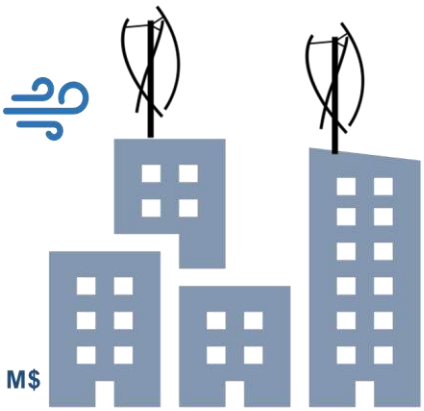
Total annual useful* generation: 33 GWh
(that is equivalent to the annual electricity consumption of 1,380 households)

Required capital investments: 83 (2020) M$

Total amount of avoided electricity cost in 2030: 3.2 (2020) M$/year
(as if each residential elecricity bill in the city was reduced by 27%)



Urbain wind turbine

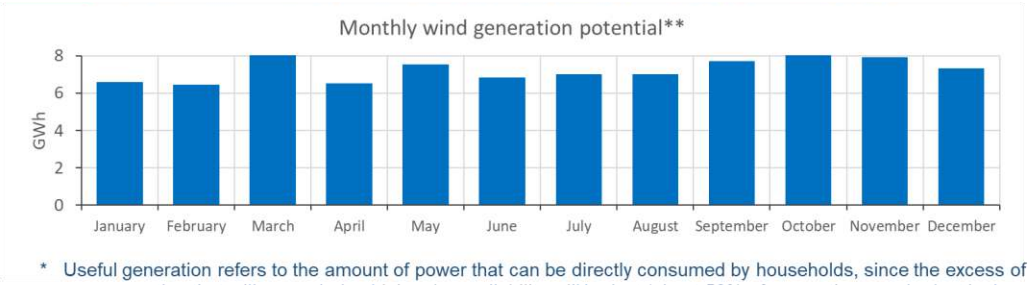


Installed capacity: 13 MW
(about 9% of total rooftop potential in Ekibastuz)

Total annual useful generation: 2,4 GWh
(that is equivalent to the annual electricity consumption of 100 households)

Required capital investments: 74 (2020) M$

Total amount of avoided electricity cost in 2030: 0.23 (2020) M$/year
(as if each residential electricity bill in the city was reduced by the additional 2%)

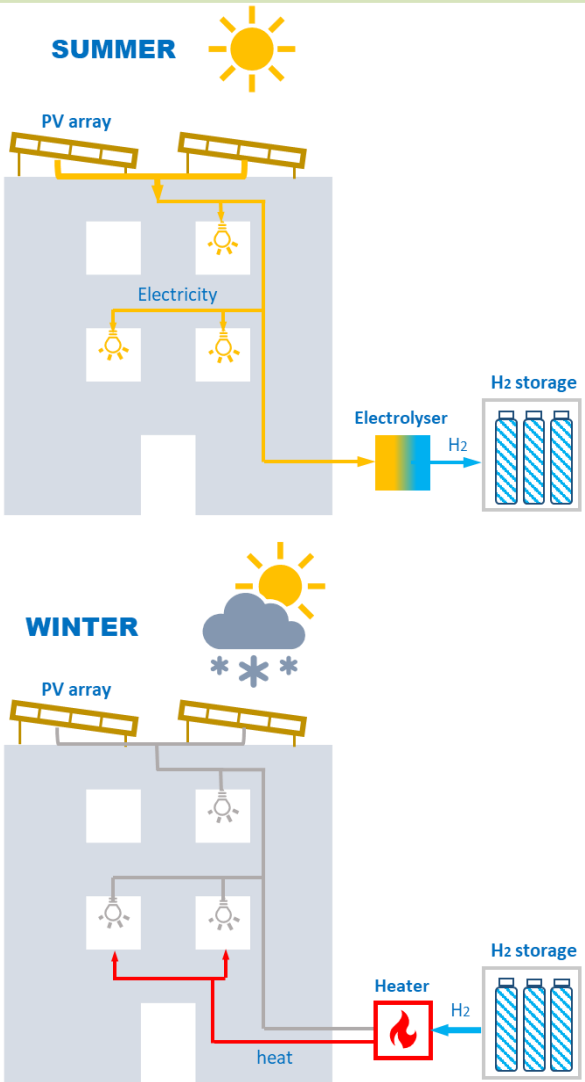


* Useful generation refers to the amount of power that can be directly consumed by households, since the excess of power generation that will occur during high solar availability will be lost (about 50% of generation may be lost in the absence of electric battery, 30% may be still lost in the presence of battery)
** Estimated based on historical hourly time series for irradiation, wind speed and temperature in Ekibastuz.

ENERGY SUPPLY RESILIENCY

The question of energy resiliency is crucial in cities with cold climates. In the middle of the recent winter (2022-2023) at the outside temperature dropping up to -30°C several districts of Ekibastuz were affected by the loss of electricity and heating. While, electricity could be restored, the heating absence remained for several weeks due to heat pipes that burst because of the cold.

It is clear that the priority is to adopt different measures to upgrade the existing infrastructure. At the next stage, the Carbon Neutrality Strategy may bring promising solutions to increase energy (especially heat) supply resiliency for Ekibastuz residential sector. One of these solutions, may the implementation of PV array co-located with hydrogen seasonal storage. The excess of PV generation in summer could be converted into hydrogen and stored until it is needed (typically during cold periods). In case of failures depriving buildings from centralized heating, the stored hydrogen may be burned to heat water that will be injected at the building level and distributed among households. The technology readiness level (TRL) for different parts of this installation varies between TRL7 (system prototype) and TRL9 (proven operation).



5 storey multi-appartment building (60 appartments)

Building electricity consumption: 108 MWh/year
Building heating consumption: 750 Gcal/year

PV rooftop installed capacity: 64 MW

Total annual generation: 76.7 MWh
(33 MWh is the PV generation excess during summer period that cannot be directly used and may be converted into hydrogen and stored until winter)

Production of hydrogen: about 80,000 m^3

Full heating autonomy up to **5 days** during high cold periods (less than -20°C) and up to **11 days** during moderate cold periods (higher than -10°C)

Required capital investments: 350,000 (2020)$

RESILIENT ENERGY TRANSITION

The increase of renewable power generation under current projections may be too drastic and additional policies to smooth this transition may be required. More sustainable transition for Kazakhstan may rely, at first, on local resources (i.e., natural gas) and, at second, on green gases, such as biogas and hydrogen, that may replace natural gas by using the same infrastructure. This may help to mitigate natural gas assets stranding and decrease investments in renewable generation while still achieving carbon reduction target.

As a part of Kazakhstan and Germany cooperation, Svevind company already working in on wind and solar farms in the Mangystau Region for two years plans to couple large-scale wind and solar farms with electrolysis to produce two million tons of “green” hydrogen annually in Kazakhstan [21]. The project involves building and operating a desalination plant with 255,000 cubic meters per day, a 40 GW renewable energy station (wind, solar), and a 20 GW water electrolysis production, mainly for export or domestic consumption. The project implementation will create up to 3,500 jobs during the construction period and up to 1,800 new permanent jobs during the phased commissioning of the facilities.

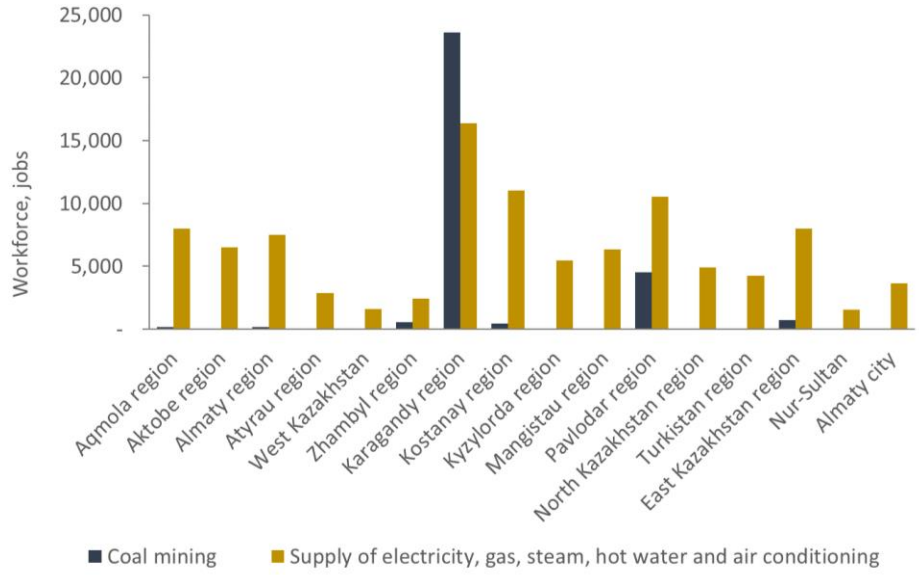
Visualization of large-scale wind farms and solar PV farms in Kazakhstan. Photo credit Svevind Energy.

4. Employment

4.1. Employment in Kazakhstan

In 2020, 30,260 workers were employed in coal mining [16] and 104,300 workers in the sector of supply of electricity, gas, steam, hot water and air conditioning [17]. By assuming that the workforce is distributed proportionally to the results of "Questionnaire for a sample survey of employment" (T-001) conducted in 2018 by the Bureau of national statistics for household members aged 15 and over, the workforce distribution depicted on **Figure 18** may be achieved. The most coal mining workforce is concentrated in coal basin regions, such as Karaganda and Pavlodar. Utility employees are spread across all regions and mostly correlated with the regional population and installed capacities (e.g., power capacities).

Figure 18. Employment in energy sectors in Kazakhstan.

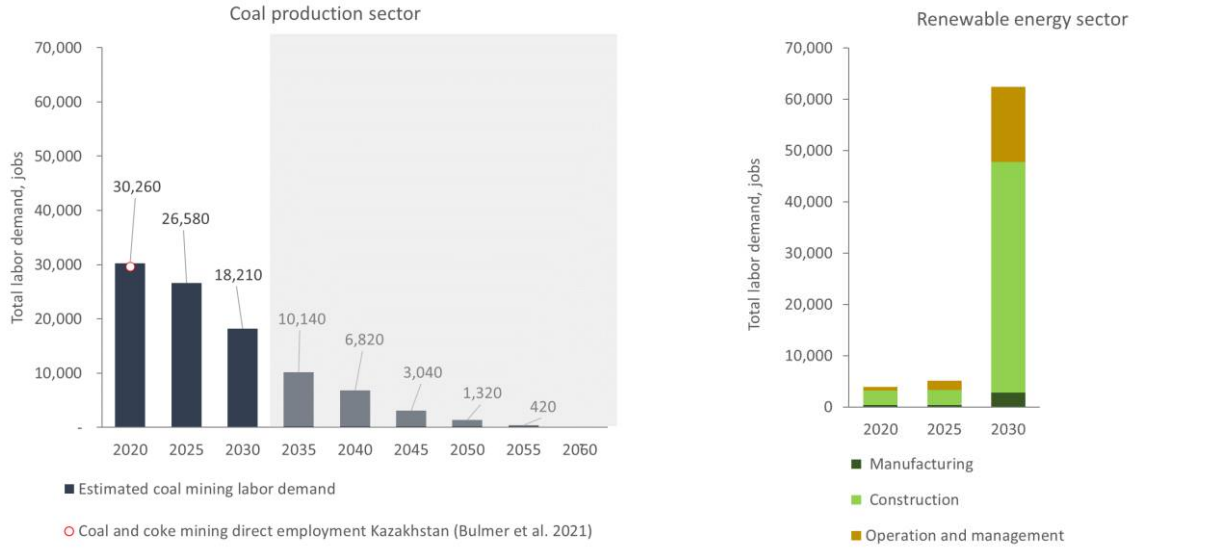


Key message	Employment in coal mining is concentrated in coal mining regions, a decrease in coal mining may increase a concentrate unemployment and will require support measures.

4.2. Labor demand in production and energy sectors in Kazakhstan

The direct employment related to coal mining may drop by 40%: from 30,260 workers in 2020 to 18,210 workers in 2030 (**Figure 19**). The employment losses from closing mines will require efforts from the government to allow workers transition towards retirement or other sectors. We can assume that the labor in coal power generation will be partly transferred to gas power generation (after coal-to-gas plant conversion). However, it is possible that not all workers may be transferred to gas-fired generation. Therefore, some labor from coal power generation may need to be trained and transitioned to renewable power generation that, according to projections, will require a significant amount of labor by 2030 (**Figure 19**).

Figure 19. Labor decrease in coal production and increase in renewable generation sector.



Key message While the decrease in labor demand in coal mining will be progressive, labor demand in labor-intensive renewable sector may increase drastically.

Renewable energy is the labor-intensive sector. Our estimations show that Kazakhstan may require more than 60,000 workers in renewable generation by 2030 to keep up with the Carbon Neutrality Strategy objectives (**Figure 19**). An important factor increasing labor demand in renewable sector will become the need to build new renewable power plants. While manufacturing labor demand will mainly occur abroad in countries manufacturing components for renewable generators (such as China), plant construction will happen at Kazakhstan territory requiring important number of qualified labor.

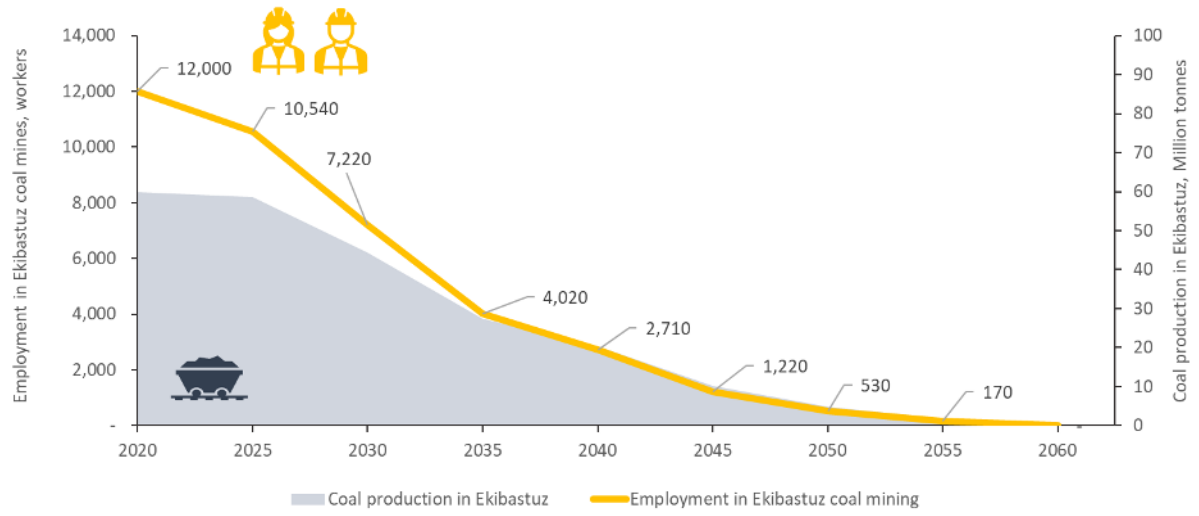
While coal phase-out may create some risks related to concentrated unemployment, gas and renewable sectors expansion may create opposite risks for labor shortage. Therefore, we provide not only suggestions for direct labor demand related to coal, gas and renewable energies, but also insights related to indirect labor demand.

4.3. Labor reallocation in Ekibastuz

Employment in conventional sectors

Following the consultation of stakeholders during Ekibastuz visit it was pointed out that Ekibastuz coal mining sector directly employs around 12,000 workers. Under the decrease of coal extraction foreseen by the Carbon Neutrality Strategy, this number of workers may decrease to about 7,220 workers in 2030 (**Figure 20**).

Figure 20. Decrease of labor demand in coal mining sector in Ekibastuz.

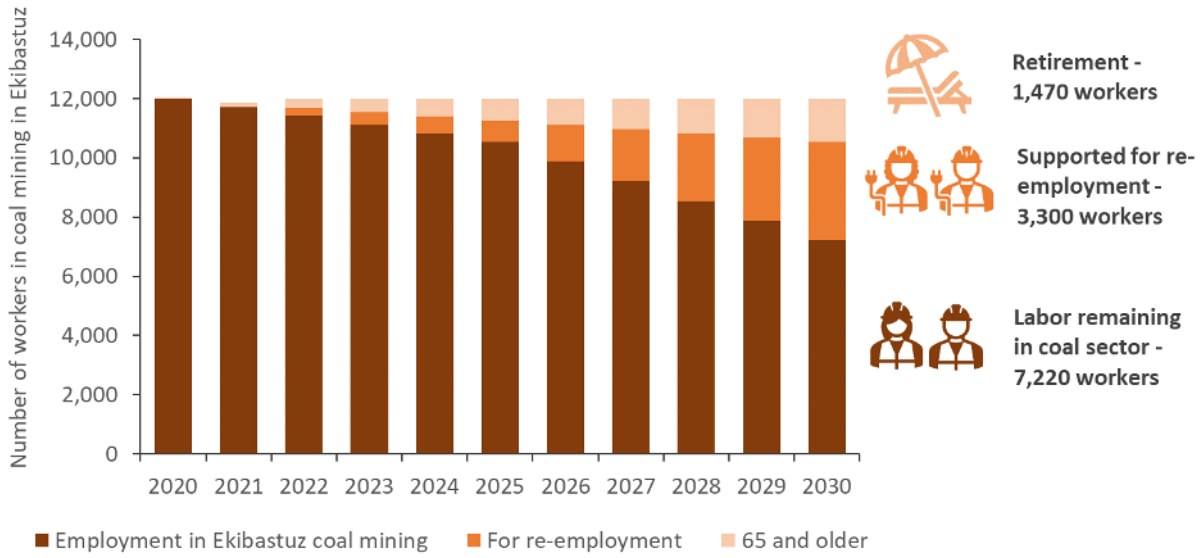


Key message	Following coal mining decrease suggested by the Carbon Neutrality Strategy labor demand of coal mining sector may decrease by 40% between 2020 and 2030.

Before 2030, around 1,470 workers are expected to retire from the coal mining sector in Ekibastuz (**Figure 21**). However, the decrease of labor demand under the Carbon Neutrality Strategy is considerably more important that the natural labor force decrease under the assumption of existing retirement and the absence of new employees. The analysis shows that between now and 2030 around 3,300 workers must be supported to allow their re-employment in other sectors.

Workers employed in power and heat production sector may remain similar and transition to the installed capacities converted to gas.

Figure 21. Retirement and expected re-employment in Ekibastuz.



Key message	Before 2030 around 1,470 workers in Ekibastuz coal mining are expected to reach the retirement age. Under the Carbon Neutrality Strategy around 3,300 workers from other age categories must be supported for re-employment in other sectors.

Employment in renewable sectors

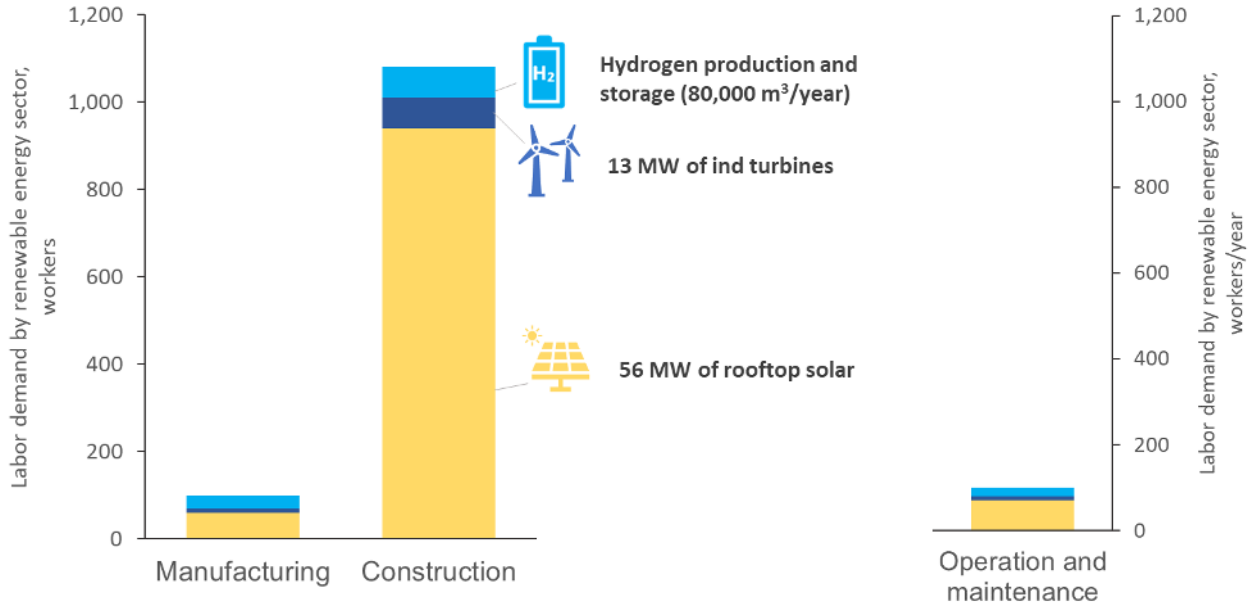
Growing renewable energy sector will demand a creation of additional jobs during the phases of technologies manufacturing, construction (or installation) and operation. The estimations of **Figure 22** relies on the potential deployment of renewable generation capacities by 2030 from **Section 3**:

- **56 MW of rooftop PV arrays**
- **13 MW of wind turbines**
- **One experimental project of seasonal storage** with the annual production of 80,000 m^3 of hydrogen.

The deployment of these renewable capacities by 2030 in Ekibastuz the following labor demands may be created:

- **Manufacturing phase** may only require about 100 local workers, since presumably most of components will be imported.
- **Construction phase** will require local qualified workers to install renewable technologies. It is the labor-intensive phase, that may create more than 1,000 jobs.
- **Operation and maintenance** of these renewable technologies will require around 100 workers annually during all technology lifespan.

Figure 22. Labor demand to build distributed renewable capacities in Ekibastuz.



Key message The construction phase would be the most labor intensive.

HEALTH EFFECT FROM COAL MINING AND COMBUSTION

Coal mining and combustion has extended effects on the environment and human health at each stage of its lifecycle:

- **Surface collapse and geological disaster.** Coal mines construction and operation may cause surface collapse and geological disaster damaging ecosystems and causing fatalities. The surface ground fissures, steps, and collapse pits caused by mining activities, not only change the original topography (change the slope and elevation of land), but also reduce the quality and fertility of land, change the soil properties, decrease crop productivity, reduce surface plants, increases soil desertification, and deteriorate the surface ecosystem [22]. When the coal mining is carried out, the damage of the overlying strata is transmitted to the surface, and the original bearing stress of the surface building (structure) will change leading to the destruction of the surface structure (affecting surface infrastructure, such as roads, buildings and power lines). In addition to direct surface disasters, landslides and collapse debris flows are also prone to occur due to the chain reaction caused by the change of surface mechanism properties [22]. According to the National Bureau of Statistics of China, mining 10,000 tons of coal will typically lead to 0.2 ha of surface collapse, in 2008 it caused $640 Million of damages and affected 40 cities [23]. The same source reports that over 500 people have been injured in geological disasters induced by coal mining in China. The data on such effect for Kazakhstan is scarce. In 2009 three people died and one was seriously injured due to mines collapse in Kazakhstan [24].
- **Spontaneous combustion and explosion.** Coal and gangue are prone to spontaneous combustions caused by the mechanism of stockpiled self-heating mainly propagated by low-temperature oxidation in presence of oxygen-rich air, microbial metabolism, the interaction of coal with water and oxidation of pyrite [25]. Factor causing risks of explosion and mine fires is related to the methane emission. The methane content of coal seams in Kazakhstan ranges from 12 to 53 m^3/tonne of mined coal [26]. It was found that Kazakhstan's coal sector emits more methane per ton of produced coal than any other large-scale coal-producing country [26]. According to the recent satellite observations, 27,500 kg/h of methane emissions were observed coming from Ekibastuz mines in October 2021, 45,289 kg/h of methane were observed coming from Bogatyr mine in January 2022 [27]. In March 2022, Bogatyr mine in Kazakhstan totaled 54,000 kg/h of methane emissions representing the emissions of around 2.6 Million cars driving for a year [27]. In 2022, a methane explosion at a coal mine in Karaganda has killed at least five workers and injured another four [28].
- **Pollution and respiratory diseases.** Coal mines construction and operation may cause contamination of underground water by chemicals contain, such as ammonia, sulfur, sulfate, nitrates, nitric acid, tars, oils, fluorides, chlorides and other acids and metals, including sodium, iron, cyanide. Coal industry contributes significantly to air pollution – three of the five cities with the most intense air pollution, Karaganda, Shakhtinsk and Saran, host coal industries [29]. The highest SO_2 air pollution was found in Ekibastuz, where the largest two coal-fired power plants are located [29]. In addition Ekibastuz coal has particular high ash content (42-44%). North-East regions of Kazakhstan are leading in the number of detected cancer cases. In 2018, Karaganda region recorded 239 cases per 100,000 population, Pavlodar regions recorder 263 cases per 100,000 population, while the average was 184 cases per 100,000 population with lung and bronchial cancer being the second most common cancer [30].

5. Roadmap and Action plan

Category	Action	Responsible and involved authorities	2023-2026	2027-2030	Beyond 2030
To mitigate macroeconomic impact, to support industry competitiveness and local communities					
Accelerate emissions reduction	Reinforce Emissions Trading System and put in place other measures for emission-intensive fuels to decrease impact of export carbon taxes, such as CBAM.	Ministry of National Economy, Ministry of Finance, Ministry of Trade and Integration			
Support companies in their transition	Support companies transitioning toward other core businesses which development contributes to the Carbon Neutrality Strategy (for example, by developing gas and renewable generation technologies, diversifying mono-economy regions, or contributing to the decrease of carbon emissions).	Ministry of National Economy, Ministry of Finance			
Support affected communities	Grants for local communities affected by coal phase-out to promote innovation and local development	Ministry of National Economy, Local Akimats			
Establish efficient governance structure	Put in place an efficient and independent governance entity that will undertake consultations with workers, communities, non-governmental organizations, business and industry leaders, and other relevant bodies; provides recommendations to government.	Various Federal Ministries, Local Akimats, Business associations, Consumers right protection			
Avoid coal mines abandonment	Put in place regulation for coal mines and associated infrastructure to avoid sites abandonment; attract investors for land reclamation projects	Ministry of Ecology, Geology and Natural Resources, Ministry of Regional Development, Local Akimats			
To support energy security and system reliability					
Revise actual tariff regulations	Revise actual tariff regulation and establish a clear plan on how it may evolve in the future; align with subsidies for different stakeholders.	Ministry of Energy, Ministry of Finance			
Incentives to decrease gas re-injection	Incentivize oil producer to search for different solutions to maintain oil pressure in the reservoir.	Ministry of Oil and Gas, Ministry of Industry and Infrastructure Development, Local Akimats			
Continue efforts to decrease further flared gases	Additional policies may be introduced to decrease even further flared gases	Ministry of Oil and Gas, Ministry of Industry and Infrastructure Development, Local Akimats			
Develop adaptive gas infrastructure	Promote the deployment of gas infrastructure that may take higher blends on hydrogen to mitigate assets stranding.	Ministry of Oil and Gas, Ministry of Industry and Infrastructure Development, Local Akimats			

Category	Action	Responsible and involved authorities	2023-2026	2027-2030	Beyond 2030
Promote biogas production and use and develop hydrogen strategy	Explore and develop more clear strategies related to biogases and hydrogen in connection with policies on adaptive gas infrastructure.	Ministry of Industry and Infrastructure Development			
Economic incentive to increase energy system efficiency and reliability	One of the main barriers for the increase of electric power and heat system efficiency and reliability lies in the strong regulation of end-use tariffs. Actual tariffs are not sufficient to recover actual costs and invest in additional efficiency and reliability measures.	Ministry of National Economy, Ministry of Industry and Infrastructure Development, Local Akimats			
To ensure energy affordability and to facilitate energy switch					
Subsidies for gas connection	Provide financial support to capital investment to connect to gas distribution and replace existing equipment.	Ministry of National Economy, Ministry of Labour and Social Protection of the Population, Local Akimats			
Energy affordability	Support low-income consumers in their energy expenses.	Ministry of National Economy, Ministry of Labour and Social Protection of the Population, Local Akimats			
Subsidies for users willing to become prosumers	Support end-user willing to invest in distributed renewable generation and become electricity and heat producers.	Ministry of National Economy, Ministry of Labour and Social Protection of the Population, Local Akimats			
Reduce loans	Reduce loans for residential buildings and companies using renewable generation	Ministry of National Economy, Ministry of Labour and Social Protection of the Population			
Buildings retrofit	Reinforce building energy standard and initiate renovation plan.	Ministry of National Economy (Committee for Construction, Housing and Communal Services and Land Management), Local Akimats			
To support energy sector transition					
Emission standard	Reinforce power-related emission standard and control over it.	Ministry of Ecology, Geology and Natural Resources, Ministry of National Economy			
Premiums payments	Reward companies that are able to exceed their carbon reduction objectives in relation with existing standard.	Ministry of Ecology, Geology and Natural Resources, Ministry of National Economy			

Category	Action	Responsible and involved authorities	2023-2026	2027-2030	Beyond 2030
Criteria for higher efficiency	Put in place criteria for high efficiency in new installations.	Ministry of Ecology, Geology and Natural Resources			
Particular conditions for converted plants	Plants converted from coal to gas may have higher emissions than gas plants. To promote coal-to-gas plants conversion particular conditions (reliefs) may be adopted for these plants.	Ministry of Ecology, Geology and Natural Resources, Ministry of National Economy			
Financial incentives for renewable generators	Put in place financial incentives at different levels (such as taxes reduction as federal level and grants at regional level).	Ministry of Ecology, Geology and Natural Resources, Ministry of National Economy			
Facilitate land access	Develop a coherent plan that will facilitate land access for renewable projects.	Ministry of National Economy (Committee for Construction, Housing and Communal Services and Land Management), Ministry of Agriculture, Local Akimats			
Facilitate renewable generation connection	Expanding electricity transmission and distribution infrastructure and reviewing interconnection and cost allocation rules for new generators.	Ministry of Industry and Infrastructure Development, Ministry of National Economy			
To support labor reallocation, to mitigate concentrate unemployment and labor shortage					
On-site career counselling and support for workforce transition	Career consultation one-on-one or in groups to develop individualized plan for career transition.	Ministry of Labour and Social Protection of the Population, Local Akimats			
Workforce adjustment committee specific to each site	Train facilitators that will help to identify what supports and services are needed from government and other organizations, and how those supports should be tailored to meet specific needs of coal workers. Facilitators may assist to develop a specific transition plan for each coal mine.	Ministry of Labour and Social Protection of the Population, Local Akimats			
Support employers in their work force transition	Help employers in their workforce transition plans, provide support for labor training courses.	Ministry of Labour and Social Protection of the Population, Ministry of Industry and Infrastructure Development, Local Akimats			
Bridging to re-employment	Provide an allowance (% of previous earnings) to workers transitioning between a job in coal mining and other sectors.	Ministry of Labour and Social Protection of the Population, Ministry of Industry and Infrastructure Development, Local Akimats			

Category	Action	Responsible and involved authorities	2023-2026	2027-2030	Beyond 2030
Bridge to retirement	Provide financial assistance to workers who are close to retirement.	Ministry of Labour and Social Protection of the Population, Local Akimats			
Provide a relocation assistance	Provide financial support and assistance to workers from coal mining starting new jobs further than a certain distance from their previous employment.	Ministry of Labour and Social Protection of the Population, Local Akimats			
Provide tuition vouchers	Provide allowance eligible for coal workers pursuing their studies.	Ministry of Labour and Social Protection of the Population, Local Akimats			
Bridge from coal to renewable sector	Promote labor bridge programs providing training and facilitating transition from coal jobs to employment in renewable generation.	Ministry of Labour and Social Protection of the Population, Ministry of Industry and Infrastructure Development, Local Akimats			
Increase employment of youth and under-represented groups	Attract population groups currently under-represented in energy (such as women).	Ministry of Labour and Social Protection of the Population, Local Akimats			
Boost automation and advanced manufacturing	Increase labor productivity by investing in technologies improvement	Ministry of Labour and Social Protection of the Population, Ministry of Industry and Infrastructure Development, Local Akimats			
Promote other labor productivity drivers	Consider to promote other drivers proven effective to improve labor productivity, i.e., innovation, education, health, support institutions, macroeconomic stability and gender equality.	Ministry of Labour and Social Protection of the Population, Ministry of Industry and Infrastructure Development, Local Akimats			

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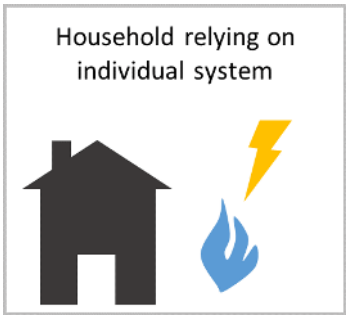
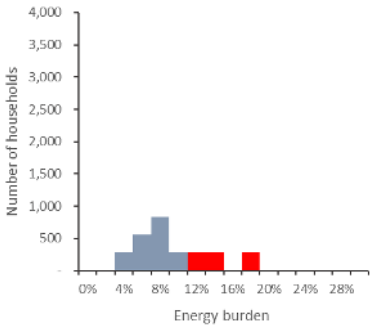
Appendix 1. How many households in Ekibastuz may be affected by energy poverty with and without subsidies?

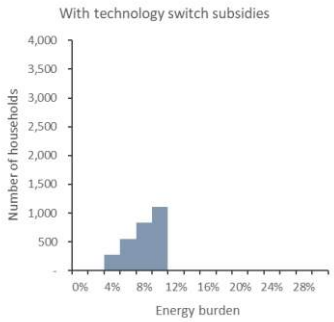
Coal phase-out under regulated tariffs

Without subsidies | **With subsidies**

Capital investments in gas connection and old equipment replacement



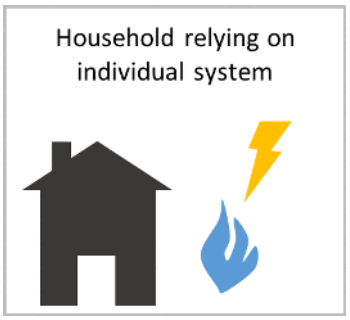


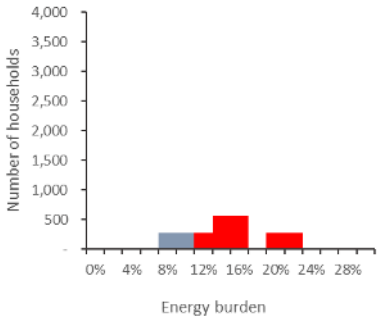


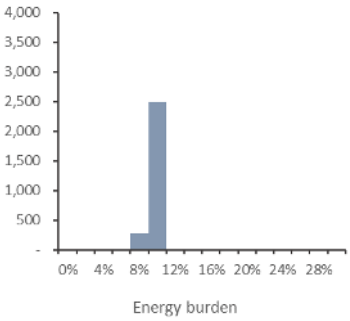
Coal phase-out under regulated tariffs

Without subsidies | **With subsidies**

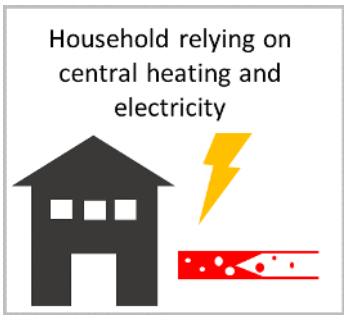
Capital investments in gas connection and old equipment replacement, and increase of energy tariffs

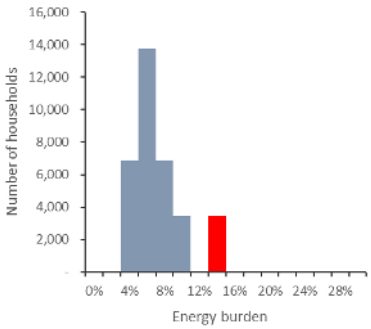


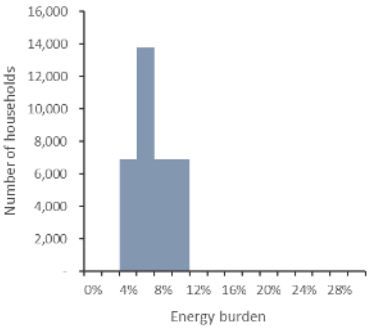




Increase of energy tariffs







- Energy poor households (may struggle to pay their energy bills)