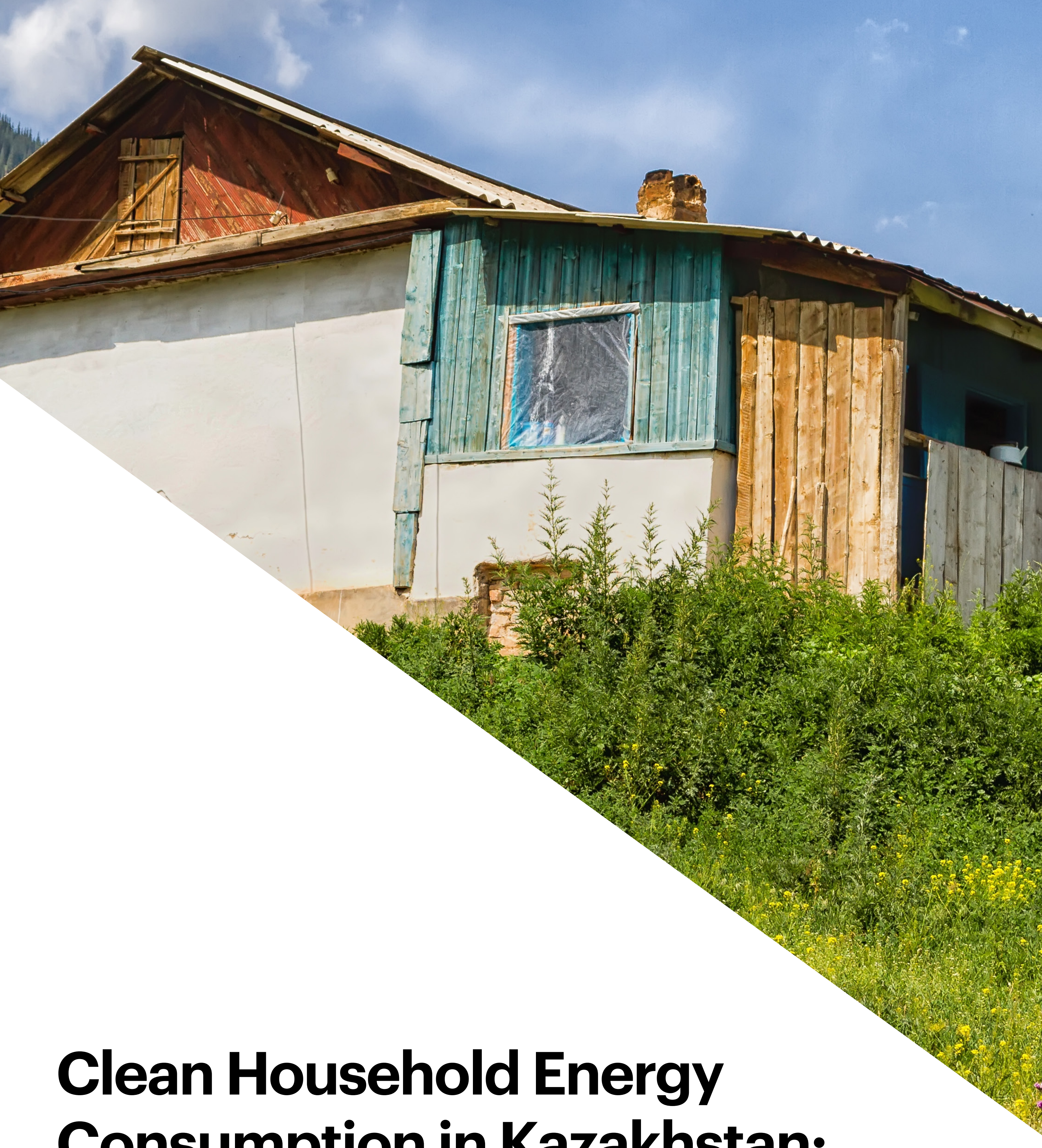

Clean Household Energy Consumption in Kazakhstan: A Roadmap

International Energy Agency

EU4Energy

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Introduction

The Republic of Kazakhstan (Kazakhstan) is one of the world's coldest countries. In most of its regions, the heating season lasts more than six months, varying from 143 to 231 days, and the annual average temperature ranges from 2°C in the north to 13°C in the south. Heating is therefore a basic survival need. Despite the country having a 100% electrification rate, solid fuels are widely used for heating owing to their availability and affordability, and because other alternatives such as natural gas and district heating are not universally accessible. According to the Household Survey on Fuel and Energy Consumption conducted by the Bureau of National Statistics, Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, 30% of Kazakh households used coal and/or firewood in 2018. Coal is burned mostly in dwellings at low efficiency, significantly reducing outdoor and indoor air quality and severely affecting health.

Small-scale residential coal burning is one of the most important sources of air pollution in Kazakhstan. In 2018, household coal combustion created 99% of residential sector particulate matter 2.5 (PM2.5), carbon monoxide (CO), sulphur oxide (SOx) and non-methane volatile organic compound (NMVOC) emissions, and 88% of nitrogen oxide (NOx) emissions.[1] Particulate matter pollution in Kazakhstan causes approximately 2 800 premature deaths per year (according to 2011 data) and costs the economy more than USD 1.3 billion annually (or 0.9% of GDP) through increased healthcare costs (World Bank and Ministry of Environment and Water Resources, 2013). High rural consumption of solid fuels is a factor that limits economic development in these regions and contributes to migration from rural to urban areas (Stoyak, Kumyzbayeva and Ibragimova, 2017).

Kazakhstan has a Nationally Determined Contribution (NDC) with an unconditional target to reduce greenhouse gas emissions (GHG)[2] by 15% by 2030 from 1990 levels. The household sector is one of the important sources of GHG emissions, amounting to 8% of national total CO_2 emissions in 2018 (UNFCCC, 2020). The residential sector is the fastest growing sector in terms of energy consumption, with the residential share of consumption increasing from 9% of total final consumption for Kazakhstan in 2000 to 27% in 2018 (IEA, 2020).

Many countries have either completely banned or severely restricted the household use of coal (especially in large cities) to curb emissions and reduce deaths from air pollution, and some have even launched special programmes and subsidies to replace coal stoves with cleaner alternatives. Although Kazakhstan has enlarged gas network access in some of its regions in recent years, network gas is still unavailable in many areas. Carefully targeted and co-ordinated policy actions that focus on rural and remote areas could certainly speed Kazakhstan's energy transition.

This study's primary aim is to explore ways to reduce heating-related residential sector emissions using a scenario analysis approach as the basis of a roadmap for Kazakhstan. The purpose of this roadmap is to help Kazakhstan formulate a policy framework and conditions to enable a household energy-use transition. It is intended to support and guide key government authorities as well as other stakeholders.

[1] Estimates based on household survey data conducted in 2018 and housing stock statistics (methodology for extrapolation described in Annex: Methodological Detail).
[2] Including emissions from land use, land use change and forestry (LULUCF).

This report analyses primary data from the 21 000 households that participated in the household survey (conducted by the Bureau of National Statistics, Agency for Strategic Planning and Reforms of the Republic of Kazakhstan in 2018)[3] to estimate national residential energy consumption, highly disaggregated according to fuel, region, house type and urban/rural divide. Four scenarios were designed to study the effects of additional measures – in comparison with no such measures – on energy consumption and emissions. The aim of the measures explored in these scenarios was primarily to reduce emissions of pollutants (and greenhouse gases) from the households sector. Although the government's present plan to expand the gas network is a step in the right direction, greater effort may be needed for a more effective, full (i.e. covering all regions) and fair energy transition. Under current policies, progress in improving energy efficiency in buildings and adopting clean heating technologies is likely to be slow. The scenarios were therefore designed to test the implications of additional actions such as accelerated fuel switching, energy efficiency interventions, and targeted aid to purchase alternative sources of heat.

As the supply side of heat generation and heating networks falls outside the scope of this study, analysis is limited to energy efficiency measures and clean heating options at the level of residential buildings.

Section 2 of this report presents historical household solid fuel consumption based on data from the household survey. While Section 3 presents scenario assumptions and Section 4 addresses results (including policy implications), Section 5 summarises the roadmap's timeline. The methodology, including a description of the household survey, is explained in the Annex.

[3] See "Annex: Methodological Detail" for a detailed description of the household survey.

Background

Heating represents around 60% of household end-use energy demand in Kazakhstan (UNDP, 2012). District heating systems based on co-generation[4] and heat-only boilers (HOBs) are common in most cities, while in the areas where district heating is not available (e.g. rural), households rely on either natural gas or coal, depending on infrastructure availability (i.e. gas network access).

Kazakhstan has rich coal resources that, at the current level of production (~100 million tonnes per year [Mt/y]), should last more than 200 years. While coal is used widely for large-scale power and heat generation (through co-generation and HOBs), it also serves small-scale household purposes. Household coal use was very common historically, mainly for heating purposes in areas lacking access to other alternatives (e.g. gas, district heating) owing to its availability and relatively low price.

Coal-burning in household heating appliances – frequently inefficient stoves – releases hazardous pollutants such as SO_X, NO_X, black carbon (BC), polycyclic aromatic hydrocarbons (PAHs), PM and CO into both the indoor and outdoor environments (Zhao et al., 2018). Among the many cases of CO poisoning and fires caused by coal stoves every winter in Kazakhstan, one that had a strong impact occurred on 4 February 2019, when a fire from a coal stove destroyed a house and took the lives of five children in the capital city of Nur-Sultan (formerly Astana). There are unfortunately no studies that quantify the amount of indoor pollutants in homes with coal stoves and the number of deaths related to their use.

Almaty air pollution, 6 December 2018 (Photograph courtesy of Svetlana Spatar)

Household coal combustion is one of the reasons for high levels of winter air pollution in Kazakhstan (see picture). According to the analysis of data from 29 monitoring sites for 2010-12, 10 out of Kazakhstan's 11 cities failed to meet minimum EU air quality standards

[4] *Co-generation* refers to the combined production of heat and power.

(World Bank and Ministry of Environment and Water Resources, 2013). Concentrations were many times above EU annual limits, suggesting very high citizen exposure to ambient air pollution. It is clear that high levels of air pollution occur more frequently in the winter due to coal-fired heating.

In 2018, the residential sector was responsible for 30% of Kazakhstan's total final energy consumption – the second-largest consumer after industry (IEA, 2020). On average, buildings in Kazakhstan consume two to three times more energy per surface area than those in northern parts of Western Europe (UNDP, 2013). Long and cold winters, dilapidation of the housing stock and heat losses through building envelopes contribute to high energy consumption for heating. At the level of the buildings themselves, energy savings of 40-55% could be achieved through the installation of individual automatic heat supply stations, heat insulation of the building envelope elements, and thermal insulation of pipes (UNDP, 2013).

Key institutions and stakeholders

Several authorities are responsible for different aspects of the residential sector.

The **Ministry of Industry and Infrastructure Development** has overall responsibility for the industry sector. It is also responsible for: energy efficiency and energy-saving; architectural, urban planning and construction activities; housing relations, communal services and municipal waste management; the water supply and sewerage; and the heat supply. The **Committee for Construction and Housing and Communal Services**, an agency under the Ministry of Industry and Infrastructure Development, is responsible for control and implementation in the fields of architecture, urban planning and construction activities, housing relations, communal services and municipal waste management. The **Committee for Industrial Development and Industrial Safety** of the Ministry of Industry and Infrastructure Development is in charge of energy efficiency and energy saving policy and regulation.

The **Ministry of Energy** formulates and implements state policy in the energy sector, including for power and heat generation, gas pipelines, gas supplies and renewable energy sources. The **Department of Renewable Energy Sources** of the Ministry of Energy is responsible for state policy concerning the development of renewable energy sources.

The **Ministry of Ecology, Geology and Natural Resources** is in charge of (among other things) environmental protection, development of a "green economy" and waste management.

The **Ministry of National Economy** holds responsibility for strategic planning, tax and budget policy, and regional development. The **Committee for Regulation of Natural Monopolies** of the Ministry of National Economy is tasked with controlling and regulating activities in the area of natural monopoly and socially significant markets, including price regulation of entities of socially significant markets. The **Bureau of National Statistics, Agency for Strategic Planning and Reforms of the Republic of Kazakhstan** formulates and implements state policy on statistics.

The **Kazakhstan Center for Modernization and Development of Housing and Communal Services** is a state-owned company that aims to help implement state policy on the modernisation and development of housing and communal services by improving the legal and regulatory framework and providing information and analytical services.

No single body currently has overall responsibility for the residential sector's energy transition. As the government's primary focus is currently on supply-side infrastructure and district heating systems, energy use by individual homes in rural areas remains poorly covered. The responsibilities of the various authorities therefore need to be clearly defined.

Current policy landscape for residential sector clean energy transition

Despite the residential sector being one of the major sources of pollutant and greenhouse gas (GHG) emissions, no specific support measures are in place to facilitate an energy transition, especially in areas lacking gas pipelines and district heating. Supports for clean energy in Kazakhstan consist mainly of supply-side measures in the power and heat sector and the extension of gas pipeline infrastructure.

Rural development is envisaged by the **State Programme for Development of Regions for 2020-2025** (adopted in 2019) through a higher level of "provision of social benefits and services to rural settlements in accordance with the system of regional standards". State funds are therefore being allocated to developing and repairing the social and engineering infrastructure of selected "backbone" villages. According to the programme, only 17% of rural settlements had access to pipeline natural gas in 2016, and the situation has not changed fundamentally since then. The state programme includes measures to improve the quality of life in rural settlements, but does not contain specific indicators and targeted measures to facilitate a household energy transition from coal to cleaner alternatives.

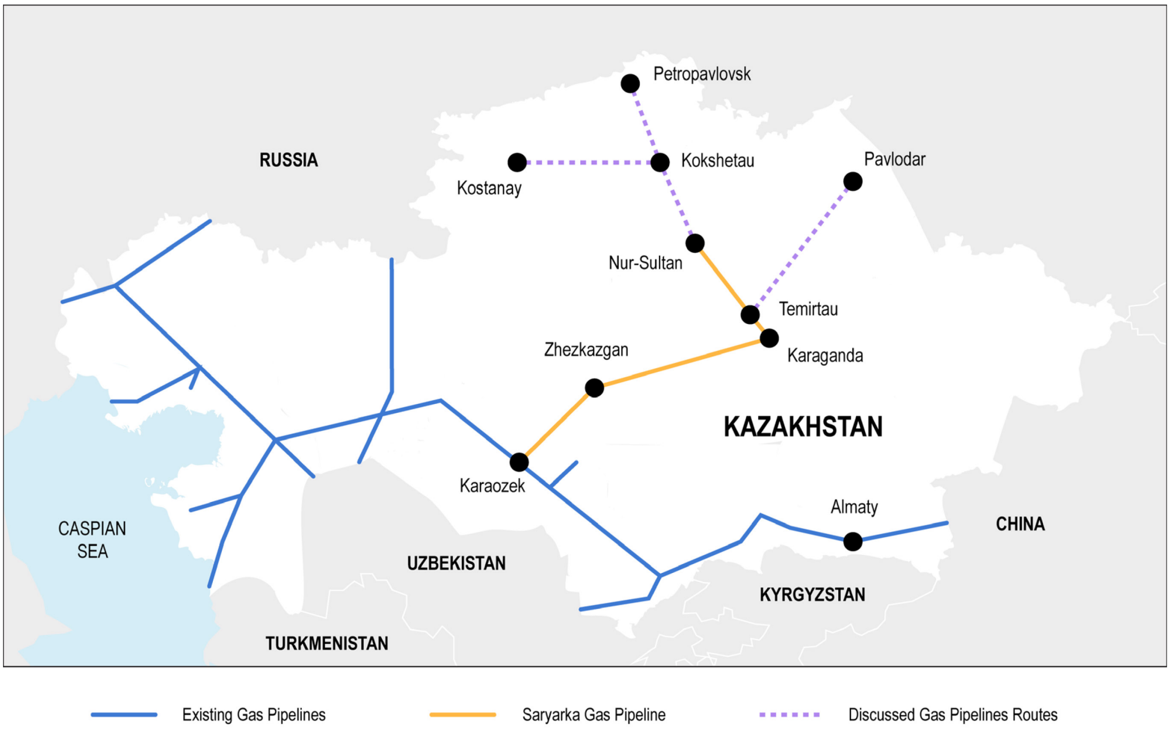
The **Environmental Code of the Republic of Kazakhstan,** adopted in 2007 (with amendments in 2020), is a piece of primary legislation that provides a framework to create an environment favourable to human life and health. Unfortunately, household coal combustion is considered the "general use" of natural resources, so emissions from the residential sector have not been regulated – and even under the Code they remain generally unrecognised, unaccounted for and neglected by government policies. Although a new draft Environmental Code was being discussed in October 2020 (expected to enter into force in 2021), residential sector emissions will continue to be unregulated.

Extension of the gas pipeline network is one goal of the state policy for infrastructure development. Construction of the gas network was funded by the state budget and state-owned company KazTransGas joint stock company (JSC), and the number of settlements connected to the gas network increased from 730 to 1 320 during the 12 years up to 2018. Domestic gas consumption has increased considerably in the past decade as a result, amounting to 13.8 billion cubic metres (bcm) in 2017 – more than 2.5 times the consumption in 2000 (5.4 bcm) (State Programme for the Development of Regions until 2020, 2018).

Natural gas is currently available in ten of the country's regions, leaving six without access (Figure 1). In 2018, former President N. Nazarbayev ordered construction of the Saryarka gas pipeline to provide gas to Nur-Sultan, as well as to central and northern Kazakhstan by 2023. Pipeline construction began in November 2018, and in October 2019 the first stage from Kyzylorda to Nur-Sultan was complete (Sputniknews, 2019). The capacity of the pipeline will be 2.2 bcm per year, supplying 171 settlements in the central regions with natural gas sourced from domestic fields in Karachaganak, Tengiz and Kashagan.

Coal consumption is expected to fall by 650 thousand tonnes (kt) per year (Inbusiness, 2019), which should improve the air quality of the capital. Even though further gas network expansion to northern Kazakhstan (the North Kazakhstan and Pavlodar regions) was initially considered under the Saryarka pipeline scheme, the timeline for extension to these regions is uncertain. Thus, three remote regions (North Kazakhstan, Pavlodar and East Kazakhstan) will probably still lack gas access in 2030.

Figure 1 Kazakhstan existing and future gas pipeline routes



Source: Aiymgul Kerimray, adapted from Tengrinews (2020).

As state heating policy in Kazakhstan focuses mainly on houses with district heating, the 2019 **State Programme for Housing and Communal Development "Nurly Zher" for 2020-2025** includes measures for capital repairs and renovations to multi-apartment buildings (MABs). Repair work to MABs is covered by funds collected from apartment owners in buildings that were previously repaired with allocations from the state budget in 2011-15. Funds collected from apartment owners for capital repairs are used by authorised organisations to repair other MABs, and according to the Programme, 826 houses will have been repaired by 2025 (222 in 2020; 444 in 2021; 40 in 2022; 40 in 2023; 40 in 2024; and 40 in 2025). Thus, the number of repaired MABs is expected to represent a very small proportion of the total housing stock. Additional measures are therefore required to advance heat insulation of houses.

The installation of metering devices for heating has accelerated in recent years. According to the **Law on Energy Saving and Energy Efficiency Improvement**, whether consumers pay for the actual cost of heat energy depends on the presence of a metering device. As of 2019, 60% of houses had metering devices for heating (State Programme for Housing and Communal Development "Nurly Zher" for 2020-2025, 2019), with 100% expected by 2025.

In accordance with the 2012 **Law on Energy Saving and Energy Efficiency Improvement,** designed and constructed buildings must comply with energy saving and energy efficiency requirements. The design documentation of buildings should contain a section on energy saving and energy efficiency, including the building's estimated energy efficiency class. Rules adopted in 2015 determine five classes of buildings based on how much the calculated (actual) value of the energy efficiency indicator deviates from the "standard" value. According to the Law**,** new and renovated buildings must have minimum class C energy efficiency level (class D or E buildings fail to comply). However, information on the number of newly constructed buildings that meet the requirements is not publicly available.

Under the **Law on Support of the Use of Renewable Energy Sources** (2009), the state provides individual consumers with targeted assistance of up to 50% of the cost of installations to use renewable energy sources (with a total capacity of up to 5 kilowatts [kW]). An individual consumer is defined as an individual or legal entity that consumes electricity and/or thermal energy from renewable energy sources, operating autonomously in non-electrified settlements and/or settlements where a centralised power supply is economically impractical. Only renewable energy installations fabricated in Kazakhstan are eligible for this support scheme. In addition, an individual consumer cannot sell electricity and/or thermal energy generated from this installation to other consumers. Even though this support measure was introduced into the law in 2014, it has not been widely exploited by households, possibly because of the narrow eligibility requirements (i.e. installations produced in Kazakhstan only, and stand-alone use).

In September 2020, the European Bank for Reconstruction and Development (EBRD) announced that it had launched a USD 30-million **Green Economy Financing Facility (GEFF)** in Kazakhstan to support green investments (EBRD, 2020). A microfinance organisation (KMF) will open a credit line of up to USD 5 million for households and small and medium-sized enterprises (SMEs) to invest in energy efficiency, climate change mitigation and adaptation projects. Loans of around USD 1 500 will be provided for investments in thermal insulation, solar photovoltaic (PV) panels, geothermal heat pumps and water-efficient irrigation systems (EBRD, 2020).

Coal combustion by households contributes to air quality deterioration in Almaty, one of the most polluted cities in Kazakhstan. In August 2020, second-tier Halyk Bank announced its plans to provide support in the form of **free connection to gas networks** for residential buildings inhabited by "**socially vulnerable groups of the population**" (Halyk Bank, 2020). Households not considered socially vulnerable have access to interest-free loans to connect to the gas supply system.

Meanwhile, the Kazakhstan government and the United Nations Development Programme-Global Environmental Finance (UNDP-GEF) unit are implementing the **Derisking Renewable Energy Investment** project during 2018-22, with a total budget of USD 4.5 million (UNDP, 2020). The goal of the project is to help the Kazakh government improve the country's investment climate to encourage renewable energy sites nationwide. In its analysis of small-scale renewable facilities with a capacity of 1 kW to 1 000 kW, the project estimated that Kazakhstan has 5 907 such facilities with total electrical capacity of 17.8 megawatts (MW) and heat capacity of 54.1 MW. Most (96%) were installed by individual enterprises, and 97.5% are solar power stations. Barriers to the wider use of small-scale renewables in Kazakhstan are: insufficient support measures for the population; complicated grid connection procedures; and insufficient support for SMEs. The government was advised to: i) subsidise capital expenditures for small-scale renewables; and ii) adopt simple, easy-to-understand conditions for grid connection and operations. Household subsidies for 60-80% of the cost of a renewable energy facility with a capacity of up to 20 kW were suggested. A number of other recommendations were also made to the government within the framework of the project, particularly several amendments to the Law on Support of the Use of Renewable Energy Sources (2009), including:

- Separate legal regulation of small-scale renewables (less than 400 kW) intended primarily to meet the owner's own needs.
- Subsidies (at the initial stage) to stimulate the local services and production market for small-scale renewables (solar collectors, heat pumps, Astana solar).
- Exclusion of the existing support-mechanism requirements that installations must be fabricated in Kazakhstan only and that beneficiaries must reside in non-electrified areas only, as Kazakhstan now has an electrification rate of nearly 100%.

Solid fuel use by Kazakh households

The household survey results show that 30% of Kazakhstan's households used coal and/or firewood in 2018: 17% urban and 55% rural. Survey data demonstrate that household fuel use varies significantly by region due to differences in climate, access to infrastructure and shares of housing types. Thus, solid fuel use differs for urban versus rural dwellers, and for detached houses compared with MABs. In urban areas, 5% of apartments and 46% of detached houses used solid fuels, while in rural areas it was 31% of apartments and 68% of detached houses (Figure 2).

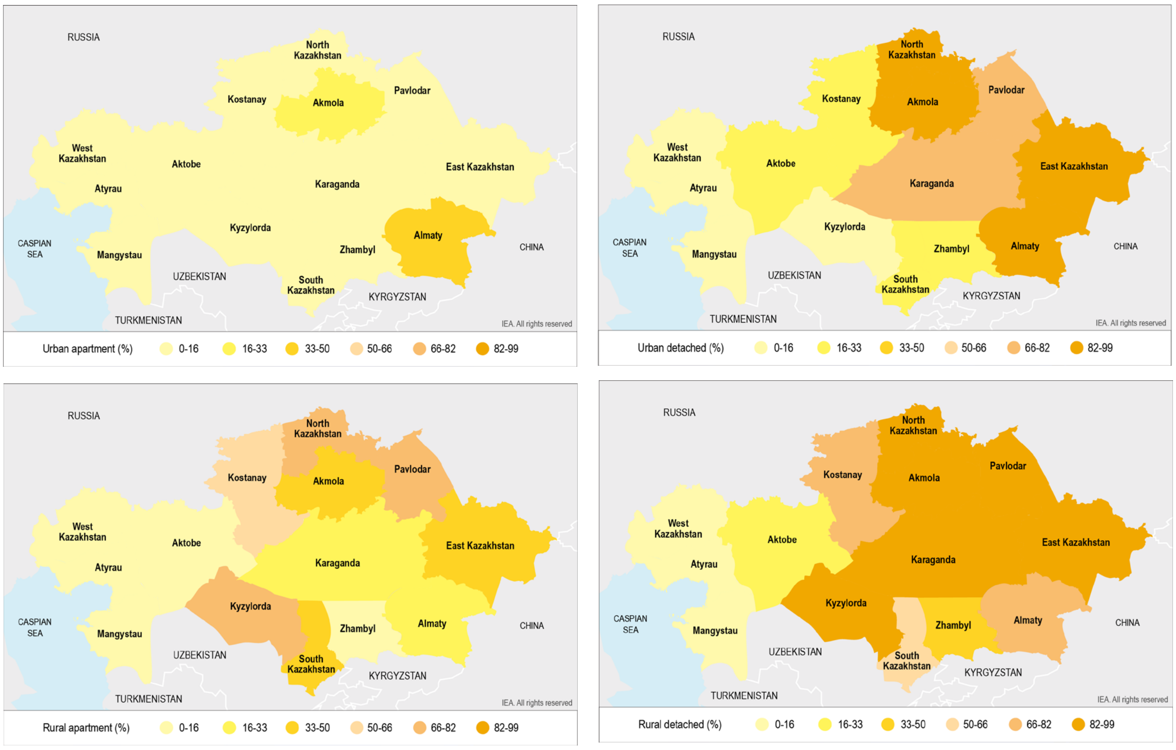
Solid fuels use is more prevalent in regions where district heating and natural gas are unavailable – i.e. the rural areas of northern, central and eastern Kazakhstan. The share of rural detached houses using solid fuels was very high in regions without gas pipelines: East Kazakhstan (99%), North Kazakhstan (99%), Pavlodar (99%), Akmola (98%) and Karaganda (95%). Regions with a gas pipeline network (mainly in western Kazakhstan) have substantially lower solid fuel use in rural detached houses: Mangistau (0%), West Kazakhstan (1%), Atyrau (4%), Aktobe (29%) and Zhambyl (37%).

In 4 regions out of 14, however, solid fuel use remains high among detached rural households despite access to pipeline natural gas: Kyzylorda (95%), Almaty (81%), South Kazakhstan (57%) and Kostanay (80%). In these regions, households continue to rely on coal – possibly because of the high cost of connecting to the pipeline, the expense of a gas boiler, the relatively higher price of gas, distribution network unavailability, and/or income poverty. Specific support programmes (e.g. subsidies) to help households switch from coal to gas are not yet in place.

Low population density is one of the limiting factors for gas pipeline development. In 2018, Kazakhstan's average population density in was 6.8 people per square kilometre (/km^2), varying by region from 2.9/km^2 to 17.4/km^2 (Bureau of National Statistics, Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, 2020).

Regions in Central Kazakhstan (Nur-Sultan city and the Karaganda and Akmola regions) that currently rely heavily on coal are expected to gradually switch to gas in upcoming years, owing to completion of the Saryarka gas pipeline in 2019 and ongoing extension of the gas distribution network.

Figure 2 Kazakhstan households using solid fuels, by housing type

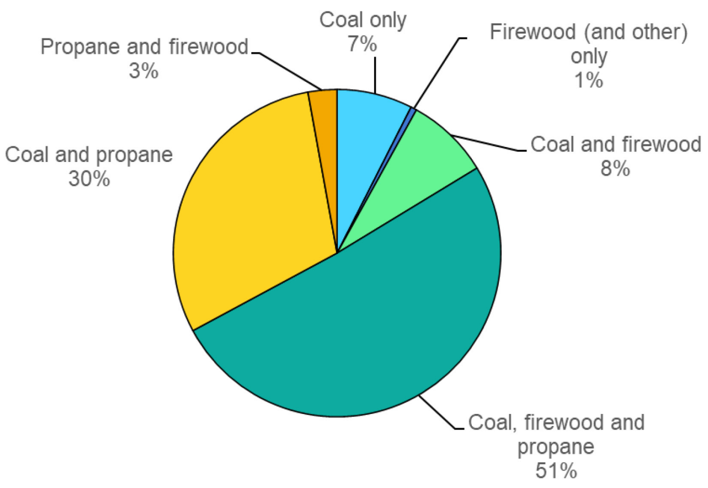


Note: "Solid fuels" refers to coal and firewood.

Source: Adapted from the Household Survey on Fuel and Energy Consumption (Bureau of National Statistics, Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, 2018).

Most households tend to use several types of fuel during the year rather than just one (Figure 3). Only 7% of households using solid fuels relied exclusively on coal in 2018, whereas 51% used a combination of coal, firewood and propane, and 30% used coal and propane. Propane (when used with coal) was used for cooking in 93% of households. Firewood alone was used by only 1% of households; it was used mainly in combination with coal and propane.

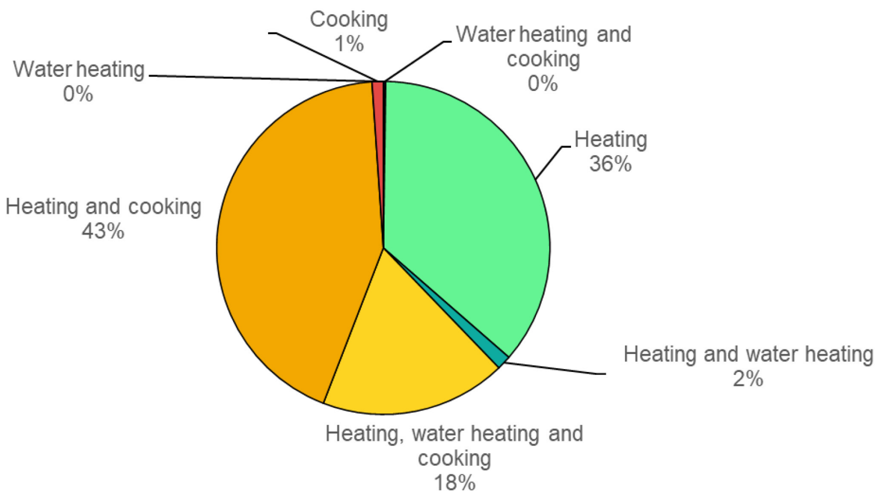
Figure 3 Kazakhstan households using solid fuels, by fuel combination



Source: Adapted from the Household Survey on Fuel and Energy Consumption (Bureau of National Statistics, Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, 2018).

The use of solid fuels was diverse in 2018: 43% of households used coal for heating and cooking; 36% used it for heating; and 18% for heating, water heating and cooking (Figure 4). Concerning firewood, 40% of households used it for heating; 31% for heating and cooking; and 15% for heating, water heating and cooking.

Figure 4 Kazakhstan household coal consumption, by end use



Source: Adapted from the Household Survey on Fuel and Energy Consumption (Bureau of National Statistics, Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, 2018).

Stove designs, operation times, fuel heating values, fuel characteristics and emissions rates can vary significantly from one household to another. There are currently no studies that quantify indoor air pollution in Kazakh households or the efficiencies of their heating devices, nor were studies found for other post-soviet countries with potentially similar heating devices and emissions rates. While wealthier urban households may have modern boilers (water-based heating), poorer ones may have to rely on hand-made brick stoves (heating based on air radiation).

Kazakhstan solid fuel stoves (Photographs courtesy of Aiymgul Kerimray)

Average daily coal consumption per household was analysed based on data from the household survey (Table 1).[5] This indicator varied significantly – from 6 kilogrammes (kg) to 46 kg (the number of heating days in a year ranges from 143 to 222, depending on the region). Some regions with a gas network (and a warmer climate) had lower daily coal consumption: Almaty (16 kg), West Kazakhstan (15-17 kg) and Aktobe (21-24 kg). However, some warmer regions (with a gas network) had relatively high average daily coal consumption: Zhambyl (35 kg) and South Kazakhstan (39-46 kg). Thus, although most regions are in line with average daily coal consumption in the Hebei Province of the People's Republic of China (hereafter, "China") (25-30 kg) (Zhao et al., 2018), Kazakhstan's national average consumption per day was 31 kg in urban areas and 33 kg in rural areas. Unsurprisingly, rural coal consumption is generally higher than urban use.

Table 1 Average daily coal consumption per surveyed household by surface area

	Coal consumption (t)		t/house/yr		kg/m^2		kg/day/house	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Akmola region	2 151	1 663	5.8	5.9	87	77	27	27
Aktobe region	206	223	4.2	4.9	67	60	21	24
Almaty region	3 225	2 997	5.0	5.0	78	66	28	28
Atyrau	0	25		5.0		54		
West Kazakhstan region	14	3	3.4	3.0	51	36	17	15
Zhambyl region	306	985	5.8	5.8	82	71	35	35

[5] Likely reporting errors were identified (i.e. households reporting unrealistically high fuel consumption) and excluded from the analysis of fuel consumption. Therefore, households using more than 10 t of coal (310 households) were omitted from the analysis.

	Coal consumption (t)		t/house/yr		kg/m^2		kg/day/house	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Karaganda region	2 179	1 476	6.8	6.7	91	88	32	31
Kostanay region	200	2 129	4.2	6.2	73	93	19	29
Kyzylorda region	100	1 422	4.5	4.8	49	45	27	28
Mangistau region	0	0						
South Kazakhstan	1 325	3 927	5.6	6.5	64	64	39	46
Pavlodar region	367	1 706	5.7	6.1	92	86	27	29
North Kazakhstan region	407	1 697	4.5	5.1	70	69	20	23
East Kazakhstan region	1 360	3 154	4.3	5.1	80	85	21	25
Nur-Sultan	92	0	1.3		13		6	
Almaty	71	0	2.7		34		16	
Total	12 001	21 405	5.2	5.6	76	72	31	33

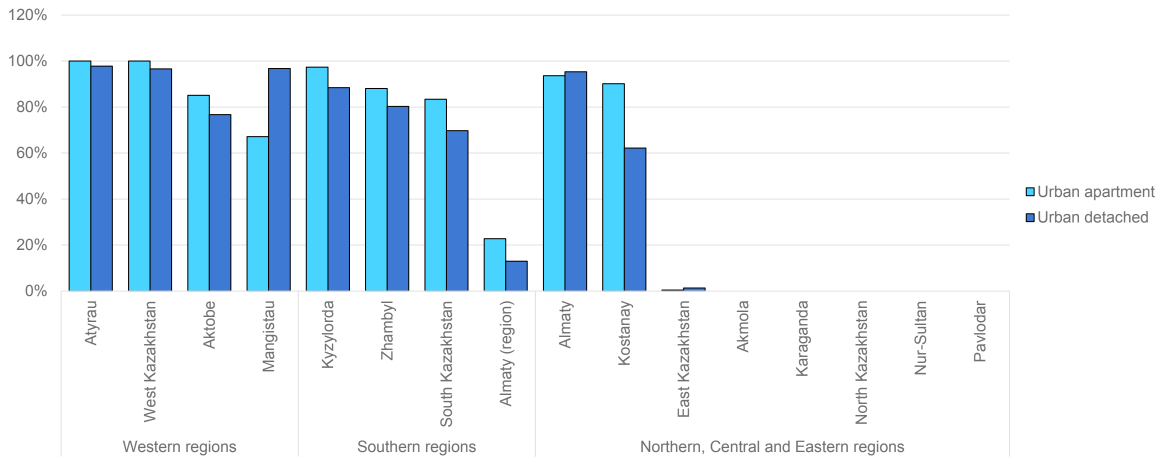
Source: Adapted from the Households Survey on Fuel and Energy Consumption (Bureau of National Statistics, Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, 2018).

The correlation between average coal consumption and duration of the region's heating season was perhaps less strong than anticipated. The general trend is for daily coal consumption to be higher in regions with shorter heating periods, which could result from greater stove and building efficiency in the colder regions. Households in colder climates may also try to save their coal.

Natural gas use by Kazakh households

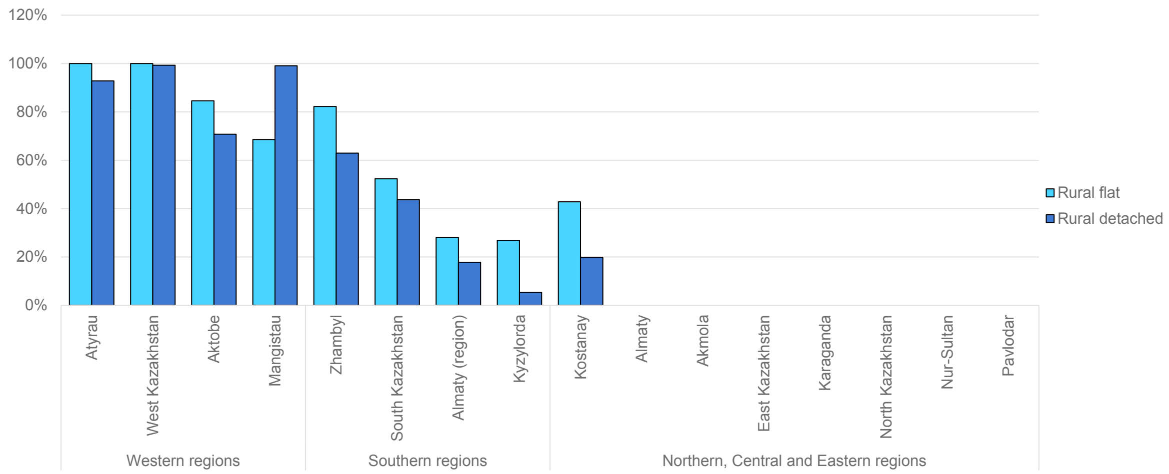
Use of natural gas by households is dependent on the availability of natural gas network and price (Figure 5, Figure 6). Out of 21 000 surveyed households, 41% were using natural gas (for all purposes, including for heating, water heating and cooking purposes). The share of natural users by house type was as follows: 45% of urban apartments, 50% of urban detached houses, 31% of rural apartments and 31% of rural detached houses. Majority of the households in the western regions of Kazakhstan rely on natural gas due to the developed gas pipeline infrastructure and low gas prices. There is a main gas pipeline available in the southern regions of Kazakhstan, but share of gas is relatively low in rural areas due to relatively high cost of connection, higher prices of gas and lack of distribution pipelines. Regions in the north, center and east of Kazakhstan do not use natural gas (except for Kostanay region) due to unavailibility of natural gas pipeline and gas supplies.

Figure 5 Share of urban households using natural gas, by housing type



Source: Adapted from the Households Survey on Fuel and Energy Consumption (Bureau of National Statistics, Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, 2018).

Figure 6 Share of rural households using natural gas, by housing type



Source: Adapted from the Households Survey on Fuel and Energy Consumption (Bureau of National Statistics, Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, 2018).

Scenario description

Four pathways/scenarios for future household energy consumption have been developed to explore the implications of taking additional measures, compared with a business-as-usual (BaU) case. Existing government plans to provide wider regional access to gas pipelines is an important measure that will certainly reduce coal consumption. However, greater efforts could be needed to realise a more effective, fuller (i.e. covering all regions) and fairer energy transition, such as energy efficiency intervention programmes for households and targeted aid to purchase alternative sources of heat. The scenarios are therefore designed to test the implications of such additional actions on energy consumption and emissions. The aim of the measures explored in these scenarios was primarily to reduce emissions of pollutants (and greenhouse gases) from the household sector. Each consecutive scenario contains measures additional to the previous one (Figure 7). Table 2 presents each scenario's assumptions and the policy implications of those assumptions.

Figure 7 Scenario design

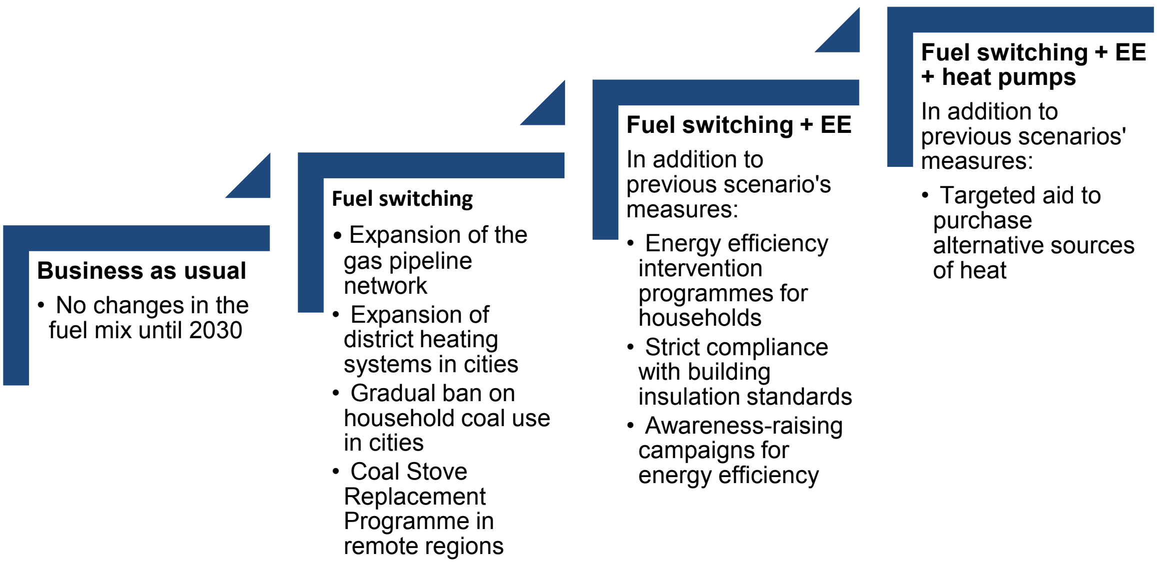


Table 2 Scenario assumptions and policy implications

Scenario name	Scenario assumptions	Policy implications
Business-as-usual (BaU) scenario	Current shares of fuel use by house type remain unchanged to 2030. Energy efficiency improvement rate same as in the past.	Existing policies
Fuel-switching scenario	Gas network expands to connect Nur-Sultan city, Akmola region and Karaganda region (as currently planned by the government with construction of the new Saryarka pipeline connecting northern and southern Kazakhstan). All households using coal in Nur-Sultan city, the Akmola region and the Karaganda region switch to natural gas by 2030. In urban apartments in all regions, coal consumption is fully phased out by 2030 through the expansion of district heating systems. Three regions remain without gas network access: North Kazakhstan, East Kazakhstan and Pavlodar. They will switch from coal stoves (47% efficiency) to improved coal boilers (75% efficiency) in rural houses. Gas provides the remaining energy needed for heating in all regions (except North Kazakhstan, East Kazakhstan and Pavlodar) for all house types (except urban apartments).	• Implementation of current government plans to **extend the gas pipeline** to Central and North Kazakhstan. • **Tariff reforms for gas, electricity and district heating** to create favourable investment conditions for the supply sector. • **Gradual household coal ban in cities** with gas pipeline network. • **Subsidisation of connections to gas pipelines** or gas boiler purchases for low-income and vulnerable households. • Launch of the **Coal Stove Replacement Programme** in regions without a gas pipeline. Urban planning policies should consider providing MABs in cities with district heating systems.
Fuel-switching + energy efficiency (EE) scenario	In addition to the assumptions of previous scenario, improved energy efficiency of heating systems. For district heating: • Emissions efficiency increases from the current 90% to 95% by installing thermostatic valves on radiators. • Automatic control efficiency increases from 90% to 98% by installing automatic heat control points (to regulate indoor temperature). • Procedures for operations and maintenance and energy monitoring during operation of the building will be put in place, raising energy monitoring efficiency from 90% to 97%. • Distribution efficiency rises from 90% to 100% by insulating heating pipes and valves. For individual heating systems: • Emissions efficiency increases from 90% to 95%.	In addition to the measures above: • Launch of **energy efficiency intervention programmes for households**, such as retrofit grants, loans or tax incentives (targeted and non-targeted). • **Strict compliance with building insulation standards** to be ensured. **Awareness-raising campaigns for energy efficiency**.

Scenario name	Scenario assumptions	Policy implications
	• Procedures for operations and maintenance and EM during operation of the building will be in place, boosting EM efficiency from 90% to 97%. Gas boiler efficiency increases from the current 75% to 85%. Energy demand (in both district heating and individual heating systems) falls 15% by 2030 (from 2017 levels) thanks to energy efficiency measures in buildings (e.g. window replacements, wall insulation, etc.).	
Fuel-switching + EE + heat pumps scenario	Coal is fully phased out in all regions and all house types by 2030. Heating system energy efficiency improvements are the same as in the "fuel switching + EE" scenario. Heat pumps provide 25% of heating energy for all house types (except urban apartments) in all regions (except western regions with inexpensive and abundant gas, where heat pumps provide 15%). Heat pump heating efficiency is assumed to be 3, as the IEA-ETSAP (2012) estimates the heating efficiency of domestic heat pumps to be 2.5 to 3.6. In regions without a gas network (North Kazakhstan, East Kazakhstan and Pavlodar), remaining energy for heating is provided by propane (85% boiler efficiency) for all house types (except urban apartments). Energy demand for heating is assumed to decrease 15% owing to wall insulation and window replacements.	In addition to the measures above: **Targeted aid to purchase alternative sources of heat** (e.g. heat pumps, solar thermal installations, propane).

Scenario results

Total energy consumption for heating

Residential energy consumption for heating rises from 419 344 terajoules (TJ) in 2018 to 514 299 TJ in 2030 in the BaU scenario – an increase of 23% (Figure 8, Figure 9, Figure 10). In the fuel-switching scenario (i.e. from coal to gas), total residential energy consumption for heating amounts to 414 777 TJ in 2030, 19% lower than in the BaU scenario (because switching from coal stoves to gas boilers raises efficiency). Introducing energy efficiency measures further reduces residential energy consumption for heating to 270 574 TJ in 2030 in the fuel-switching + EE scenario, putting it 47% lower than the BaU level. In the fuel-switching + EE + heat pumps scenario, total residential energy consumption is 234 198 TJ, which is 54% below the BaU scenario. Thus, greater heating system energy efficiency, combined with higher generation efficiency, demonstrably results in substantially lower residential energy consumption.

Figure 8 Kazakhstan residential energy consumption for heating, by scenario

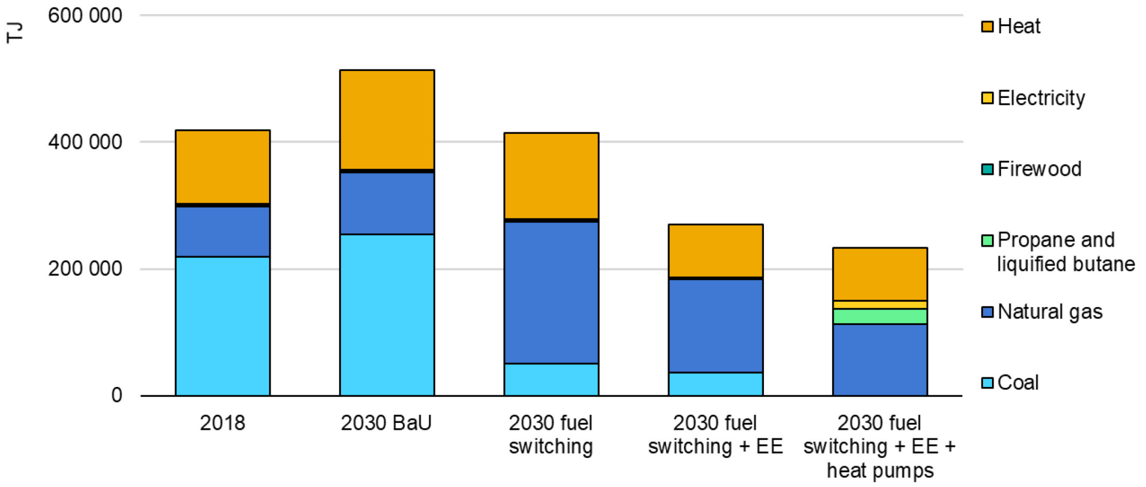


Figure 9 Kazakhstan regional residential coal consumption for heating, by scenario

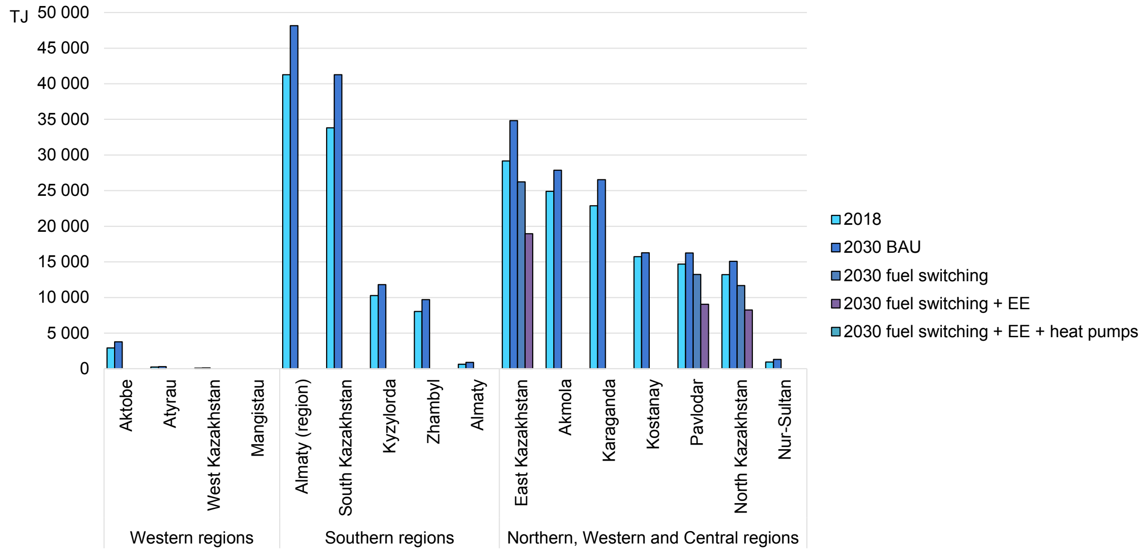
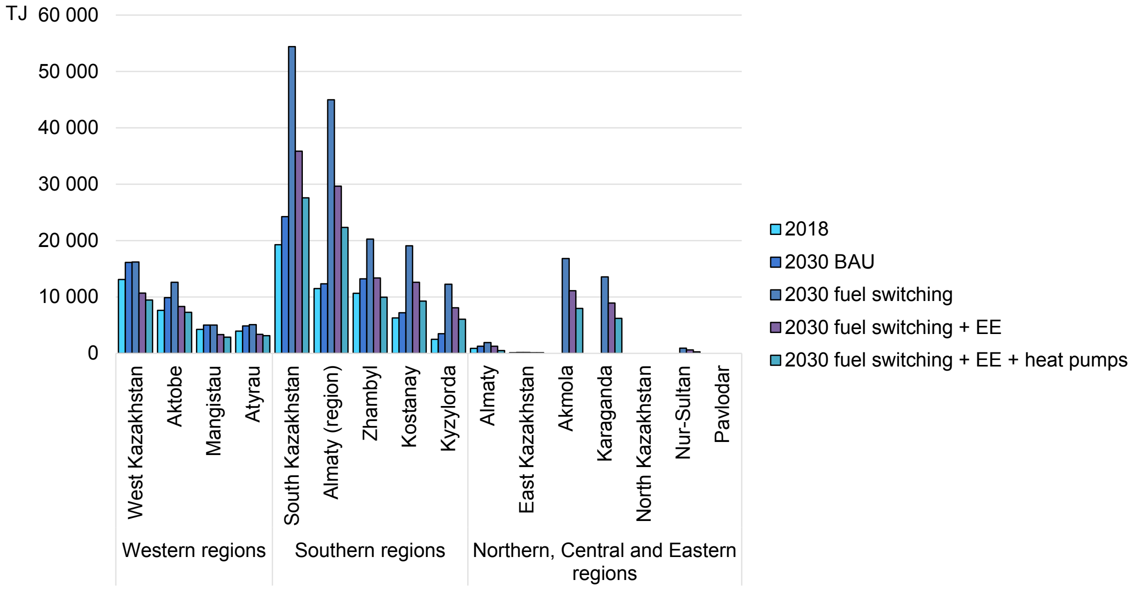


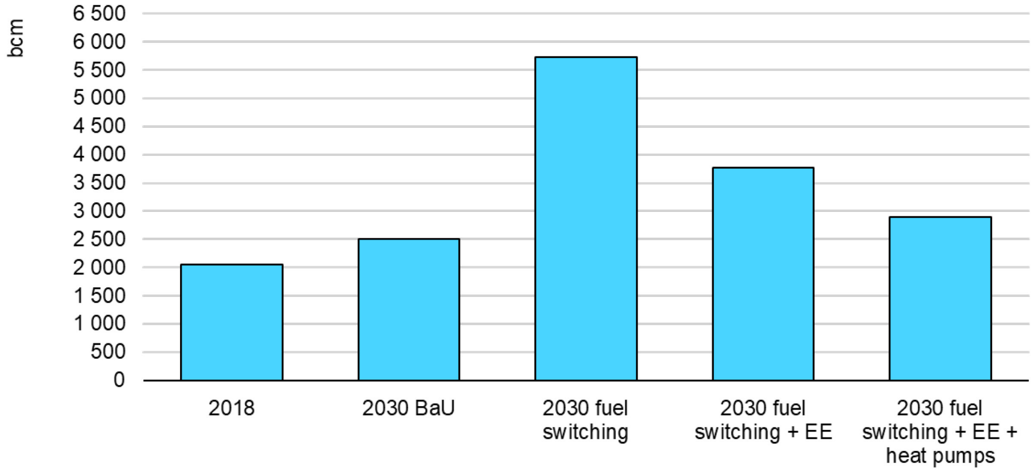
Figure 10 Kazakhstan regional residential natural gas consumption for heating, by scenario



Natural gas use by scenario and gas availability

Natural gas consumption increases in all scenarios, but by differing amounts. Without energy efficiency measures (in the fuel-switching scenario), natural gas consumption for heating rises from the current 80 082 TJ to 223 227 TJ in 2030. With energy efficiency measures (fuel-switching + EE scenario), only 147 163 TJ are required to satisfy heating demand in 2030. In the fuel-switching + EE + heat pumps scenario, even less gas is needed – just 112 893 TJ in 2030. Figure 11 depicts natural consumption for heating according to scenario (in bcm). Energy efficiency improvements can clearly reduce natural gas consumption, which, considering availability and cost uncertainties, is likely to benefit Kazakhstan.

Figure 11 Kazakhstan natural gas consumption for heating, by scenario



China became a major importer of gas in 2018, receiving 5.2 bcm from Kazakhstan (Kazenergy, 2019). That year, Kazakhstan signed a five-year contract to export 10 bcm of gas annually via the Central Asia-China gas pipeline system. After 2023, exports are expected to fall to 8 bcm per year until 2040 to accommodate lower production volumes. Because Kazakhstan's commercial gas supplies are limited, it may be challenging to increase domestic gas consumption and also continue exporting.

Due to Kazakhstan's low regulated gas prices, KazTransGas – the national operator for gas and gas supplies, and responsible for expansion – had financial losses in 2015, which were compensated for by exports to China (Kazenergy, 2019). Therefore, any future export reductions would likely create further financial losses for the company. The gas price for residential consumers was USD 49.24 per million cubic metres (/Mcm) (KZT 18 710/Mcm) in May 2019, down from USD 56.17/Mcm (KZT 18 440/Mcm) in May 2018 (Kazenergy, 2019).

According to Kazenergy (2019), Kazakhstan has one of the world's lowest household expenditure levels for energy services (e.g. gas, electricity). At 3% of average household income in some regions, it is substantially lower than in Europe (22-23%), the Russian Federation (5-8%) and India (10-12%). Gas prices must therefore rise to incentivise greater production and provide funds for additional investment in gas transportation and distribution infrastructure (Kazenergy, 2019). Higher tariffs are also needed to encourage greater energy efficiency.

However, although higher prices would allow for development of the domestic gas pipeline infrastructure, raising the cost of gas may also encourage households to continue relying on coal. Additional measures to regulate the transition from coal to gas are therefore necessary, such as a coal ban in the cities and support for low-income and vulnerable populations to cover energy expenditures. Strict control of compliance with coal bans in cities should be ensured by local authorities to eliminate illegal coal trading; the coal ban must be announced in advance; and a transitional period should be provided for households to switch to other options.

Box 1 Natural gas market deregulation in several countries

In the 1970s, excessive regulation of natural gas producers resulted in gas supply shortages in the United States. The first step in deregulating the gas market was adoption of the Natural Gas Policy Act in 1978 (Waheed and Malik, 2009). In 1985, a Federal Energy Regulatory Commission order was issued to begin deregulating the transmission industry, and in 1992 the Federal Energy Regulatory Commission passed an order that opened access to transmission lines and unbundled pipeline merchants and transportation functions. As a result, the United States now has the most deregulated gas market and prices are based on the supply-demand balance (Waheed and Malik, 2009).

The United Kingdom followed the US example to successfully establish a fully deregulated, competitive and mature market by 1998. The UK spot market is mature, restructuring of the transmission segment is enforced by short-term contracts, and gas prices are determined by the supply-demand balance. During 1999–2005, UK gas prices rose at an average annual rate of 43% (Waheed and Malik, 2009).

In Australia as well, gas transmission has been undergoing substantial deregulation and restructuring since the 1990s (Waheed and Malik, 2009).

China has also taken steps towards gas market liberalisation in recent years. It has already achieved progress through some price deregulation and by allowing third-party access and unbundling infrastructure (IEA, 2019).

Other fuels

Energy efficiency measures reduce district heat consumption 38% more in 2030 in the fuel-switching + EE scenario than in the fuel-switching scenario, which implies reductions in supply-side emissions (i.e. from co-generation and heat plants). Consumption of district heating in 2030 is estimated at 135 502 TJ in the fuel-switching scenario and 83 679 TJ in the fuel-switching + EE scenario.

The bulk of district heating (74%) is currently generated by large plants with capacities of more than 100 gigacalories per hour (Gcal/h), mainly co-generation units and HOBs. HOBs in a few cities in western and southern Kazakhstan use gas (UNDP, 2007), but all the others rely on coal. Therefore, most district heating (65%) in 2014 was based on coal, the remaining on natural gas (32%) and oil (3%) (Kerimray, Kolyagin and Suleimenov, 2018). Unfortunately, more recent data are not available on heat generation according to fuel. Furthermore, as the supply side of power and heat generation falls outside the scope of this study, future reports need to research scenarios for supply-side emissions reductions.

Electricity consumption rises 21% from 2 451 TJ in 2017 to 2 977 TJ in 2030 under the BaU and fuel-switching scenarios. With energy efficiency measures in the fuel-switching + EE scenario, however, it decreases to 2 224 TJ – a reduction of 10% from 2017.

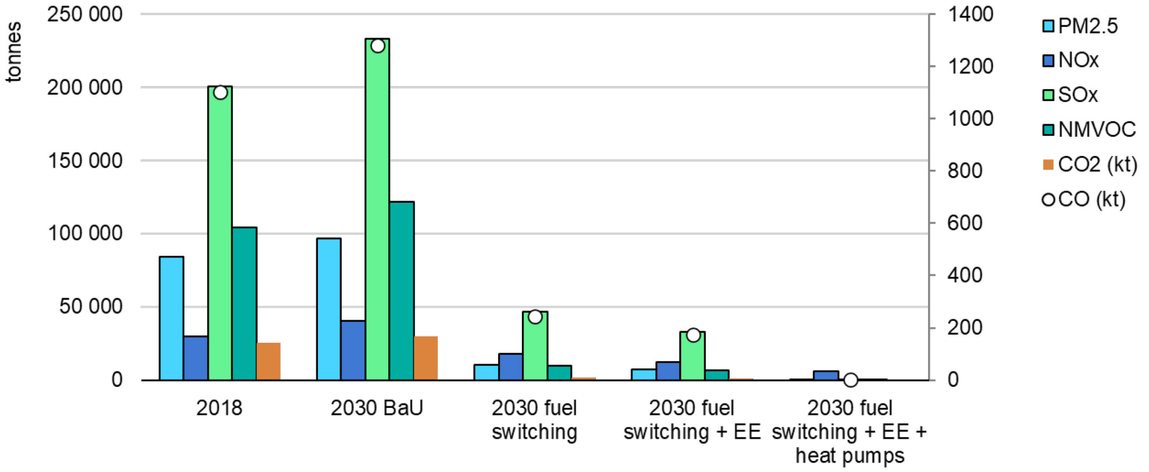
Heat pump use in the fuel-switching + EE + heat pumps scenario increases electricity use by five times the current level, raising it to 12 841 TJ in 2030. This implies the need for additional electricity generation by power plants.

Pollution from coal-fired power plants in Kazakhstan is considerably higher than from those in Europe: by 900% for PM, by 20% for NOx and by 150% for SOx (Decree of the President of the Republic of Kazakhstan, 2013). Coal combustion at power plants could, however, be made more efficient and less emissions-intensive through the installation of emissions control technologies. Additionally, greater renewables-based generation would help meet future electricity demand without increasing pollution or emissions.

Emissions by scenario

In the BaU scenario, emissions levels rise from 2018 to 2030 for PM2.5 (+15%), CO (+16%), NOx (+36%), SOx (+16%), and NMVOC (+16%), while the alternative scenarios demonstrate that substantial reductions can be achieved. A simple switch from coal to gas and increased efficiency (through using coal boilers instead of coal stoves in three regions) reduce emissions of PM2.5 88% from the 2018 level by 2030, as well as CO (-78%), NOx (-41%), SOx (-77%) and NMVOC (-91%). Additional energy efficiency measures (fuel switching + EE) would further reduce emissions of PM2.5 by 91%, CO by 84%, NOx by 60%, SOx by 83% and NMVOC by 94%. Full coal phaseout and the use of heat pumps (fuel switching + EE + heat pumps) results in nearly zero pollutant emissions from residential heating (Figure 12, Figure 13).

Figure 12 Kazakhstan pollutant emissions from residential heating, by scenario



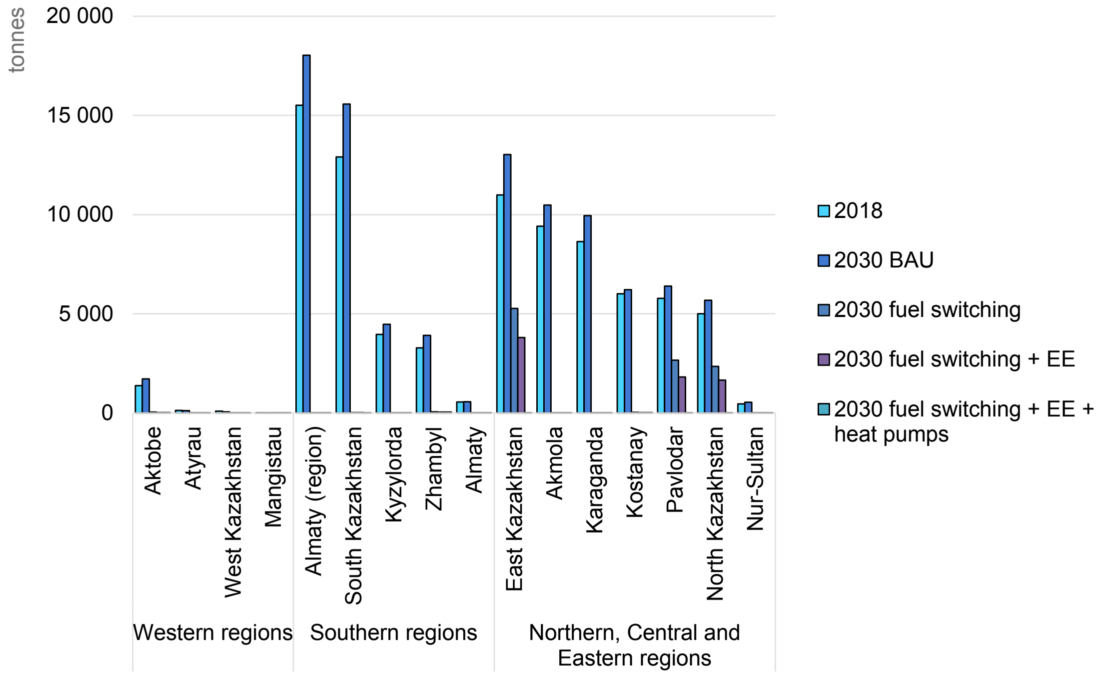
NO_X emissions reductions in the alternative scenarios are smaller than for other pollutants (PM2.5, CO, SO_x and NMVOC) because natural gas combustion generates some NOx emissions but virtually none of the other pollutants. In 2018, nearly all (99%) of PM2.5, CO, SO_x and NMVOC emissions were generated from coal burning, whereas 88% of NOx emissions resulted from coal and the remainder from natural gas (12%).

Greenhouse gas emissions, including CO_2, were also analysed in this study. Emissions of CO_2 from household heating are estimated to rise from 25.5 mln t in 2018 to 29.8 mln t in

2030 in the BaU scenario. Meanwhile in the other scenarios CO_2 emissions fall by 93%, 96% and 98% in fuel-switching, fuel -switching + EE, and fuel-switching + EE + heat pumps, respectively.

Figure 13 presents PM2.5 emissions by region and scenario. Due to high coal consumption, the Almaty, South Kazakhstan and East Kazakhstan regions had high PM2.5 emissions in the base year. Three remote regions (North Kazakhstan, East Kazakhstan and Pavlodar) would need additional measures (e.g. propane, heat pumps) to fully eliminate PM2.5 emissions from the residential sector.

Figure 13 Kazakhstan PM2.5 emissions from residential heating, by scenario



Discussion and policy implications

Providing access to clean alternatives by constructing gas pipeline infrastructure is a key step in the household heating energy transition. The government plans to extend the gas pipeline to central regions (Nur-Sultan city first), but further extension to remote regions (North Kazakhstan, Pavlodar and East Kazakhstan) remains uncertain. Three of the alternative scenarios assume that rural detached households in all regions (except three) switch from coal to gas by 2030, implying that current government actions to construct and extend gas pipeline networks to the regions must be sustained and supported by additional measures.

However, even with gas pipeline availability, households may choose not to switch from coal to gas due to higher connection, boiler and gas costs. Additional policy measures are therefore needed to facilitate the switch from coal to gas in the areas supplied with gas. In urban areas, a **gradual ban on coal sales to households** would reduce air pollution in cities. For low-income and vulnerable households, specific support measures to **subsidise the cost to connect to a gas pipeline or to purchase a gas boiler** should be implemented.

Given the scarcity of domestic gas resources in Kazakhstan, raising energy efficiency is vital to the energy transition. **Gas price deregulation** is first necessary to stimulate investment and efficient gas use to ensure adequate future supplies. Given Kazakhstan's contractual export obligations to China, the potential to import gas from the Russian Federation, Turkmenistan or Uzbekistan should be studied further.

Energy efficiency potential in buildings is very high in Kazakhstan, as substantial heat is lost though walls, windows and heating systems. Dilapidation of the housing stock, inefficient district heating systems and overheating all contribute to high energy consumption in the residential sector. However, administrative and economic barriers hamper energy efficiency improvements: low energy prices and a lack of metering result in low homeowner interest to pay for renovations and few incentives for building maintenance and refurbishment. **Energy efficiency interventions** such as retrofit grants, loans and tax incentives (targeted and non-targeted) could therefore produce substantial energy savings. Additional measures could include strict enforcement of building insulation standards, awareness-raising campaigns and heating tariff reforms.

Box 2 Coal- and wood-burning bans in cities

Many countries have either banned or severely restricted the household use of coal to reduce emissions and minimise the impacts of air pollution.

- Since Dublin banned coal use in 1990, studies have confirmed significant reductions in black smoke concentrations and fewer respiratory illness-related deaths.
- Krakow prohibited the burning of coal and wood in 2019 to address severe air pollution, with fines imposed for breaking the ban (Radio Poland, 2019).
- Beijing has implemented a programme to ban coal and subsidise electric heat pumps and electricity expenditures in 3 700 villages surrounding the city (Barrington-Leigh et al., 2019).

The availability of relatively inexpensive coal from local mines and the lack of reliable and affordable supplies of cleaner alternatives continue to impede the energy transition. A survey on attitudes towards green energy in Kazakhstan identified the key factors preventing a switch to new sources of heat: insufficient knowledge regarding both the environmental and economic benefits of renewables; insufficient familiarity with available technologies; doubts about the economic viability of installation projects; and lack of understanding of the practical obstacles involved in implementing and maintaining renewable energy projects (Karatayev et al., 2016). Kazakhstan has only a handful of heat pump and solar water heater suppliers, and knowledge and awareness of alternative heat technologies is weak. To address this barrier, **support measures for producers and suppliers of clean heating technologies** should be adopted in tandem with efforts to provide clear, accessible information to consumers.

Even with construction of a gas pipeline to Central Kazakhstan, many remote locations in the North and East regions will still lack access to cleaner alternatives to coal. A **Coal Stove Replacement Programme** can be implemented in rural and remote regions, with subsidies offered for efficient boilers. The programme should require the exchange of old stoves as one of the subsidy conditions, with stove replacements being carefully monitored and programme effectiveness regularly evaluated. A Stove/Boiler Emissions and Efficiency Testing Laboratory could be established to test boiler models and develop eligibility criteria.

Many alternative heating technologies remain unaffordable for most households. For instance, the capital cost of a heat pump in 2013 ranged from EUR 1 100 per kilowatt thermal (/kW_{th}) to EUR 1 700/kW_{th}, depending on the type of heat pump (e.g. water-source electrically driven, ground-source electrically driven, air-source electrically driven), which is too expensive for many coal users, especially in rural areas. Kazakhstan's per capita monthly household income in 2018 was only USD 400 (Bureau of National Statistics, Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, 2019), with that of coal users generally lower yet. **Additional targeted aid to purchase alternative sources of heat** (e.g. heat pumps, liquefied petroleum gas [LPG]) is therefore needed, particularly in the three remote regions that remain without gas pipelines (Pavlodar, North Kazakhstan and East Kazakhstan).

Box 3 China and Mongolia

China's Coal-to-Electricity and Coal-to-Natural Gas programmes

In 2016, Beijing announced an ambitious Coal-to-Power Programme and a parallel Coal-to-Natural Gas Programme (Barrington-Leigh et al., 2019). The programmes ban coal burning in certain areas and offer subsidised night-time electricity tariffs as well as subsidies to purchase and install heat pumps instead of traditional coal stoves (Barrington-Leigh et al., 2019).

Mongolia Clean Stoves Initiative

In 2011, Millennium Challenge Account–Mongolia (MCA-Mongolia) financed a stove-switching project in air pollution reduction zones in five districts of Ulaanbaatar (World Bank, 2013). The Mongolian Clean Air Fund (CAF) provided additional subsidies, and 97 877 stoves had been sold by 2012, reaching 55% of all households living in the central *ger* areas of Ulaanbaatar. The low-emission stoves were sold through dedicated distribution centres called "product centres" at 60-75% below the market price (not taking the cost of chimneys and heating wall connecters into account) (World Bank, 2013).

Note: A *ger* is a circular yurt.

Box 4 Heat Roadmap Europe

The goal of the Heat Roadmap Europe (HRE) project is to collect the scientific data needed to effectively support emissions reductions in Europe's heating and cooling sector. The project has drawn several conclusions:

- In the vast majority of cities, district heating is technically and economically more viable than individual heating systems. District heating can have zero emissions when renewable energy sources, heat pumps, excess industrial heat and co-generation are used.

- Greater energy efficiency on both the consumption and supply sides is essential to reduce emissions in the heating sector. Additional support is required to achieve energy efficiency goals to renew the existing building stock.
- Thermal grid expansion is important for energy system transformation and for better integration of renewable energy sources and surplus heat.
- Recovering excess heat from industry is the key to having an efficient and sustainable heating sector. These sources can cover at least 25% of district heating production.
- District heating sources should be more varied and flexible and could include biomass boilers; various renewable energy sources; various types of excess heat; co-generation and large-scale heat pumps.
- Individual heat pumps will be a key technology in areas where district heating is not available. As heat pumps require substantial investment, often by building owners, the focus should be on policies and strategies that encourage a shift from individual boilers and inefficient electric heating to more efficient alternatives in suburban areas.

Thanks to the HRE project, natural gas consumption in Europe's heating sector is expected to be 87% lower by 2050. The project's strategies also make citizens significantly less vulnerable to high heat prices.

Roadmap timeline

The roadmap for Kazakhstan's residential sector to transition to cleaner and more energy-efficient heating was developed based on the insights of the preceding analysis. The roadmap's measures cover a ten-year period and several activity categories: policy. and strategy; data and statistics; technology; awareness-raising; and tariff reform.

ACTION	SUB-CATEGORY	RESPONSIBLE AUTHORITY	2020-23	2023-25	2026-28	2028-30
POLICY AND STRATEGY						
Include support measures (and state budget) for household energy transition in the strategic documents. Make amendments to the following strategic documents: State Programme for Development of Regions; State Programme for Housing and Communal Development "Nurly Zher" for 2020-2025; programmes for the development of territories	Policy and strategy	Ministry of National Economy Committee for Construction and Housing and Communal Services of the Ministry of Industry and Infrastructure Development Local municipalities (Akimats) of regions and cities	●			
Include regulation of emissions from the residential sector in primary environmental legislation. Introduce a gradual ban on household coal use in large cities Make amendments to the Environmental Code	Policy and strategy	Ministry of Ecology, Geology and Natural Resources	●			
Implement energy performance standards for buildings and enforce compliance	Policy and strategy	Committee for Construction and Housing and Communal Services Industrial Development and Industrial Safety Committee of the Ministry of Industry and Infrastructure Development	●			
Allocate responsibility (or expand existing functions) for residential energy transition (including rural households) to one state organisation	Policy and strategy	Committee for Construction and Housing and Communal Services Ministry of National Economy	●			
Allocate responsibility (or expand existing functions) for residential energy transition (including rural households) to one state organisation	Policy and strategy	Committee for Construction and Housing and Communal Services Ministry of National Economy	●			
DATA AND STATISTICS						
Collect data on residential end-use energy consumption. Estimate and publish residential sector energy efficiency indicators	Data and statistics	Bureau of National Statistics, Agency for Strategic Planning and Reforms	●			
In strategic planning documents, include percentage indicators for households using coal; using improved boilers; and connected to the gas network	Data and statistics	Ministry of National Economy Committee for Construction and Housing and Communal Services	●			

TARGETED INTERVENTIONS		
Introduce targeted aid for rural households to purchase alternative sources of heat (e.g. heat pumps, solar thermal, biomass) Introduce amendments to the Law on Support of Renewable Energy Sources Exclude the existing support mechanism's requirement to purchase only Kazakhstan-made installations, and lift the requirement to live only in a non-electrified area to receive subsidies, as Kazakhstan now has a nearly 100% electrification rate Adopt easy-to-understand and simple conditions for subsidy applications and household grid connections	Policy and strategy	Ministry of Energy Ministry of Finance Ministry of National Economy
Introduce targeted aid for households to purchase energy efficiency technologies Amend the Law on Energy Saving and Energy Efficiency Improvement. Offer grants for energy audits of rural homes	Policy and strategy	Industrial Development and Industrial Safety Committee Committee for Construction and Housing and Communal Services
Introduce Coal Stove Replacement Programme for rural households Test stoves at the Stove Emissions and Efficiency Testing Laboratory Establish emissions and efficiency eligibility criteria Properly monitor the effectiveness of the Programme	Policy and strategy	Committee for Construction and Housing and Communal Services
SUPPORT OF TECHNOLOGY PRODUCTION AND SUPPLY		
Introduce support measures for clean-heat producers	Technology	Industrial Development and Industrial Safety Committee
Offer capacity-building and training programmes for clean-heating technology producers	Technology	Industrial Development and Industrial Safety Committee
Improve national competencies for the production, maintenance and installation of efficient boilers	Technology	Industrial Development and Industrial Safety Committee
Establish a Stove/Boiler Emissions and Efficiency Testing Laboratory	Technology	Industrial Development and Industrial Safety Committee
Conduct awareness-raising and information campaigns on the negative impacts of coal-burning on health, and on the benefits of gas and energy efficiency	Awareness-raising	Local municipalities
TARIFFS REFORM		
Gradually phase out the administrative regulation of energy prices (so that prices reflect the full cost, including supply costs)	Tariff reform	Committee on Regulation of Natural Monopolies of the Ministry of National Economy Ministry of Energy
Enact support measures for low-income and vulnerable populations to cover energy expenditures Determine rules for low-income and vulnerable populations to be reimbursed for energy expenditures	Tariff reform	Committee on Regulation of Natural Monopolies Committee for Construction and Housing and Communal Services

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Annex: Methodological detail

Description of the Household Survey on Fuel and Energy Consumption

The Bureau of National Statistics, Agency for Strategic Planning and Reforms of the Republic of Kazakhstan conducts the Household Survey on Fuel and Energy Consumption every five years. The purpose of the survey is to collect data on household fuel and energy consumption, end-use categories (heating, cooling, lighting, cooking, water heating, use of electrical appliances) and energy sources (fuel, electricity, renewable energy) used by households in Kazakhstan.

The 2018 survey was a random sampling, conducted by interviewing households and recording information on the survey questionnaires. The sample survey covered 21 000 households, and 437 interviewers helped collect, verify and transmit data. The sampling addressed 68 940 people from all of Kazakhstan's 16 regions, covering 0.37% of the total population of 18.4 million in 2018.

Aggregated survey results are available in the statistical publication "Fuel and Energy Consumption by Households in the Republic of Kazakhstan, 2018" on the website of the Bureau of National Statistics, Agency for Strategic Planning and Reforms of the Republic of Kazakhstan (https://stat.gov.kz/official/industry/30/statistic/5). Table 3 and Table 4 present characteristics and dwelling information for urban and rural households.

Table 3 Urban household characteristics and dwelling information

	Number of households	Total surface area (m^2)	Total heated surface area (m^2)	Total number of persons	Average total surface area (m^2)	Average heated surface area (m^2)
Akmola region	691	41 499	32 483	1 861	60	47
Aktobe region	534	36 286	25 205	1 886	68	47
Almaty region	959	60 299	48 413	3 301	63	50
Atyrau	384	29 699	25 206	1 640	77	66
West Kazakhstan region	500	31 450	23 504	1 790	63	47
Zhambyl region	489	33 673	29 277	1 724	69	60
Karaganda region	1 369	82 421	78 396	4 008	60	57
Kostanay region	735	39 830	37 298	1 936	54	51
Kyzylorda region	362	30 632	22 899	1 476	85	63
Mangistau region	303	27 370	14 756	1 074	90	49

	Number of households	Total surface area (m^2)	Total heated surface area (m^2)	Total number of persons	Average total surface area (m^2)	Average heated surface area (m^2)
South Kazakhstan	1 186	117 609	78 108	4 534	99	66
Pavlodar region	798	42 691	36 461	1 994	53	46
North Kazakhstan region	423	22 414	20 567	1 009	53	49
East Kazakhstan region	1 282	66 819	46 842	3 063	52	37
Nur-Sultan	1 180	78 852	71 451	3 667	67	61
Almaty	2 590	166 183	150 246	6 305	64	58
Total	**13 785**	**907 727**	**741 112**	**41 268**	**66**	**54**

Table 4 Rural household characteristics and dwelling information

	Number of households	Total surface area (m^2)	Total heated surface area (m^2)	Total number of persons	Average total surface area (m^2)
Akmola region	434	29 579	23 158	1 319	68
Aktobe region	359	25 104	18 009	1 386	70
Almaty region	915	68 603	53 127	3 565	75
Atyrau	233	18 966	15 143	966	81
West Kazakhstan region	293	19 378	13 812	1 076	66
Zhambyl region	536	40 059	30 397	2 330	75
Karaganda region	666	39 234	37 404	1 982	59
Kostanay region	546	33 932	26 586	1 568	62
Kyzylorda region	327	33 830	24 450	1 689	103
Mangistau region	259	43 045	21 787	1 214	166
South Kazakhstan	1 092	106 912	80 505	6 016	98
Pavlodar region	325	21 359	14 670	1 038	66
North Kazakhstan region	477	32 841	25 285	1 345	69
East Kazakhstan region	753	42 658	32 088	2 178	57
Total	**7 215**	**555 500**	**416 421**	**27 672**	**67**

Main steps for constructing scenarios

This roadmap's methodology involves using primary data from the Household Survey to extrapolate at the national level and to further construct projections using scenario assumptions. Fuel use per surface area (by house type and region) among surveyed households was first analysed. Then, national-level household energy use (by house type and region) was estimated by combining data from the survey results with national-level housing stock data. Four future energy consumption scenarios were developed based on current policies and measures, with the addition of best policy practices of other countries.

1. This study obtained and analysed primary data from the Household Survey on Fuel and Energy Consumption (H-070) conducted by the Bureau of National Statistics, Agency for Strategic Planning and Reforms of the Republic of Kazakhstan among 21 000 households. Analysis was based on:
   - 4 house types (urban/rural and detached/apartment) in 16 regions (14 administrative regions and the 2 cities of Almaty and Nur-Sultan).
   - Fuel consumption by each of the 4 house types (urban/rural and detached/apartment) in the 16 regions.
   - Energy consumption by house type and region, leading to national-level estimates of corresponding surface area, energy consumption per surface area by house type and by region.

Probable reporting errors were identified (i.e. exceedingly high levels of fuel consumption reported by a few households) and were omitted from the analysis of fuel consumption per surface area. Excluded from analysis were households that reported using more than 10 000 m^3 of natural gas (213 households); more than 10 t of coal (310 households); and more than 3 t of propane (23 households). These households constitute 2.6% of surveyed households. Table 5 presents the total consumption of surveyed households by fuel type regardless of house type, after exclusions.

Table 5 Total consumption of all surveyed households, by fuel type (excluding households reporting unrealistic levels)

Region	Coal	Natural gas	Propane and liquified butane	Gas oil (diesel fuel)	Firewood	Sawdust and wood waste	Other non-food products of animal origin (manure)	Charcoal	Electricity
	t	kcm	t	t	kcm	kg	t	t	kWh
Akmola region	3 844	0	109	0	3	523	0	10	2 957 758
Aktobe region	456	1 492	29	0	134	5	89	0	1 166 547
Almaty region	6 240	1 140	501	0	3	0	81	0	3 077 943
Atyrau	25	706	2	0	5	0	0	0	930 692
West Kazakhstan region	17	2 897	6	0	12	0	8	0	1 389 154
Zhambyl region	1 312	1 444	41	0	161	5	6	0	1 471 691
Karaganda region	3 672	0	226	0	2	1 000	9	0	4 707 711
Kostanay region	2 353	928	143	0	48	0	0	0	1 813 214
Kyzylorda region	1 543	497	132	0	1	2	13	41	1 513 645
Mangistau region	0	932	166	0	0	150	2	0	1 603 367
South Kazakhstan	5 297	2 449	247	0	29	80	9	6	4 068 645
Pavlodar region	2 156	0	46	0	1	50	5	0	2 590 502
North Kazakhstan region	2 118	0	81	1	5	150	0	0	1 563 970
East Kazakhstan region	4 524	11	105	0	3	0	24	0	4 052 739
Nur-Sultan	102	0	55	6	0	0	0	0	2 557 115
Almaty	111	760	0	0	18	0	0	0	4 456 124
Total	**33 766**	**13 256**	**1 889**	**7**	**425**	**1 965**	**246**	**57**	**39 920 816**

Notes: kcm = thousand cubic metres. kWh = kilowatt hour.

2. National-level statistics on surface area were obtained from the statistical publication "About Housing Stock of the Republic of Kazakhstan in 2017".

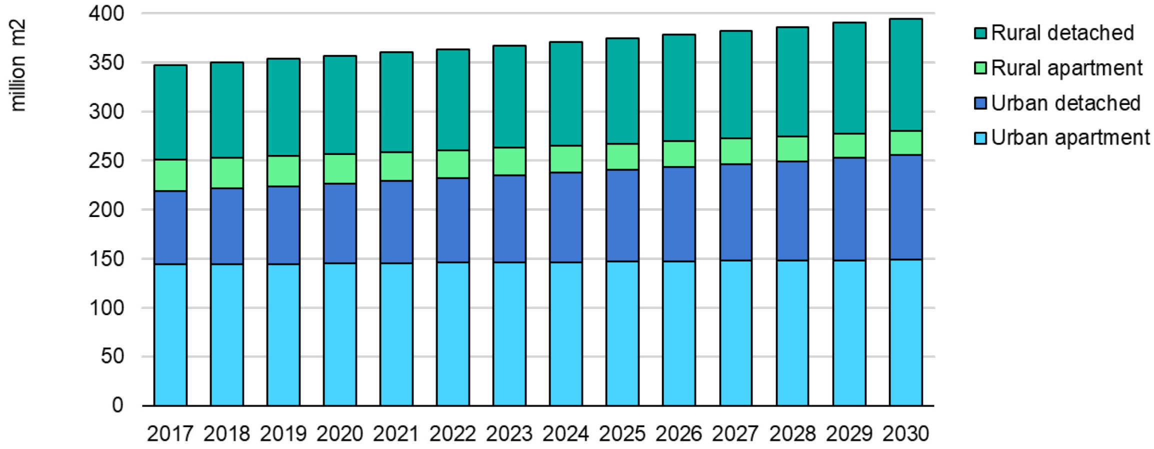
3. Residential energy consumption by house type and region (except for district heating) was estimated by applying fuel consumption per surface area from the survey and surface area data from "About Housing Stock of the Republic of Kazakhstan in 2017" using the following formula:

$$National\ estimated\ residential\ fuel\ consumption\ =\ fuel\ consumption\ per\ surface\ area\ by\ house\ type\ and\ region\ (from\ survey) \times surface\ area\ by\ house\ type\ and\ region$$

The residential energy consumption estimates were then compared with the values reported in the statistical publication "Energy Balance of the Republic of Kazakhstan".

4. Housing stock surface area projections (for the BaU scenario) were made using average annual growth rates published in "About Housing Stock of the Republic of Kazakhstan in 2017". Annual average national-level growth rates were obtained through analysis of historical values of surface area of the housing stock for 2013-17: 0.25% for an urban apartment, 2.77% for an urban detached house, -1.95% for a rural apartment and 1.3% for a rural detached house. These growth rates were applied for surface areas of all regions equally to obtain surface area projections up to 2030 (Figure 14).

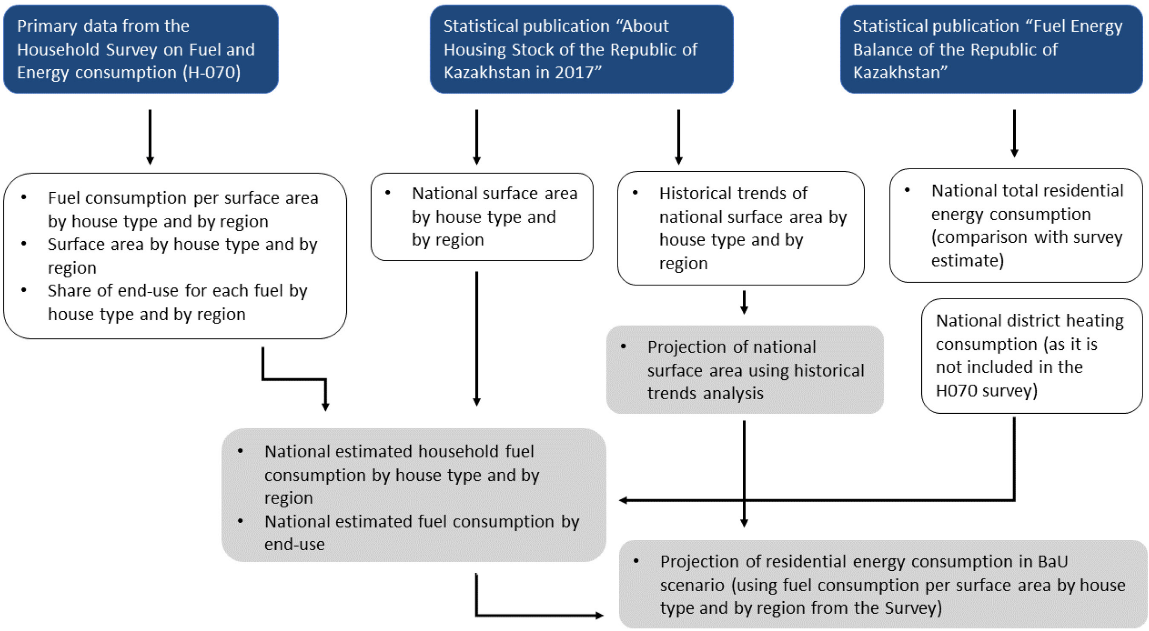
Figure 14 Kazakhstan housing stock surface area, 2017-30



5. Residential energy consumption in the BaU scenario was estimated using energy consumption per surface area by house type and region from the Household Survey. It is assumed that energy consumption per surface area will be maintained at the current level.

Figure 15 provides a simplified schematic illustrating the main steps for estimating national residential energy consumption in the base year (2018) and by 2030 (BaU case).

Figure 15 Methodology for estimating Kazakhstan residential energy consumption, 2018-30 (BaU scenario)



6. This study employed the emissions coefficients applied by the European Environment Agency (2019).

7. According to ISO 13790:2009 ("Energy performance of buildings. Calculation of energy use for space heating and cooling"), annual energy use for heating, $Q_{H,sys}$ including system losses is determined as a function of the energy needs for heating:

$$Q_{h,sys} = \frac{Q_{h,n}}{\eta_{H,sys}}$$

Where:

$Q_{h,sys}$ is the energy used by the heating system including system losses.

$Q_{h,n}$ is the energy needed for heating.

$\eta_{H,sys}$ is the overall system efficiency for heating, including generation, transport, storage, distribution and emission losses.

In this study, energy needed for heating (of a specific energy carrier *i*) was identified as:

$$Q_{h,n,i} = Q_{h,sys,i} \times \eta_{H,sys,i}$$

Overall system efficiency $\eta_{H,sys,i}$ was determined as:

$$\eta_{H,sys,i} = \eta_{dis,i}\eta_{ac,i}\eta_{TBM,i}\eta_{gen,i}\eta_{em,i}$$

η_{em} is emission efficiency.

η_{dis} is distribution efficiency

η_{ac} is automatic control efficiency.

η_{TBM} is operations and maintenance efficiency.

η_{gen} is generation efficiency.

Total energy need for heating in 2018 (for all energy carriers) $Q_{h,n}$ was estimated as:

$$Q_{H,n} = \sum Q_{H,n,i}$$

The share of fuel in total energy for heating (share of fuel i) in 2018 was estimated as:

$$Share\ of\ fuel\ i = \frac{Q_{H,n,i}}{Q_{H,n}}$$

8. Energy needed for heating in 2030 (by region and house type) was estimated based on the estimated energy needed for heating in 2018 and the surface area in 2030.

9. Assumptions of heat losses in the existing heating system had to be made because there are no studies that characterise the heat losses in Kazakhstan's residential buildings and provide information on, for example, how many buildings have thermostatic radiator valves or automatic control stations, and the amount of insulated/ pipes/valves. In the scenario that incorporates energy efficiency, heating energy needs in buildings (for both district heating and individual heating systems) are assumed to be 15% lower in 2030 than in 2017 owing to measures such as window replacements and wall insulation.

10. Study limitations and further research:

- When a household reported that it used fuel for "heating and cooking", "heating and water heating", "heating, water heating and cooking", it was assumed that the fuel was used primarily for heating, and it was not possible to break fuel use down further into precise end uses. Additional research should therefore be conducted to survey household stove operation modes, particularly to understand how stoves/boilers are used for multiple end uses, how several stoves/boilers are used within one household, and how the various fuels are used for the multiple purposes mentioned.
- For projections of surface area, this study used national-level average annual growth rates: 0.25% for urban apartments, 2.77% for urban detached houses, -1.95% for rural apartments and 1.3% for rural detached houses. Historically (2013-17), however, regional differences in surface area growth rates have been substantial. The size of urban detached houses increased in all regions except South Kazakhstan (fell by 0.86%) and Nur-Sultan (fell by 0.87%). As Nur-Sultan is the capital city, the decline in urban detached house size could be associated with the high cost of land, a shortage of available land and severe winter climatic conditions. Meanwhile, substantial growth in urban detached house surface area was observed in Almaty city (+1.53%) and the Aktobe region (+1.61%), and considerable decreases were registered in cold rural regions such as Pavlodar, North Kazakhstan and East Kazakhstan. Importantly, the surface area decreased for all housing types in both urban and rural areas in South Kazakhstan even though there was no decline in the region's population. Regional differences in growth rates were not taken into consideration because it is not clear whether these trends will continue in the future, as internal migration between regions may not last long term. This interregional migration therefore needs to be investigated further to gain an understanding of the factors and drivers involved.

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