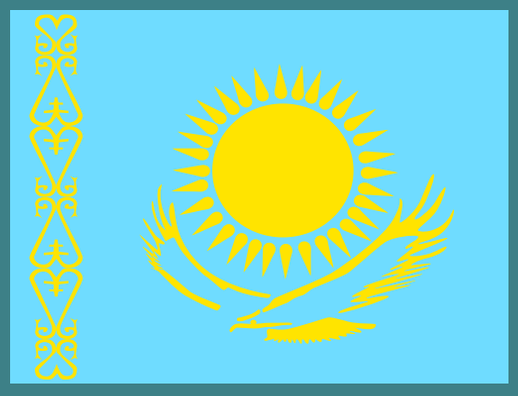
UNECE

March 2024

Kazakhstan's Energy Brief



Executive Summary

Kazakhstan is the largest emitter of CO2 in Central Asia, with a CO2 intensity of GDP 70% higher than the global average. The energy sector accounts for roughly 85% of the country's emissions, with electricity and heat generation, alone, contributing to over 50% of energy sector CO2 emissions. Fossil fuels dominate the energy mix, with coal constituting almost 50% of the share, whilst renewable energy accounts for only 1.6% of Kazakhstan's total energy supply in 2021.

Kazakhstan must scale low carbon deep electrification across all sectors. With electricity demand expected to rise by close to 60% in the next decade and coal accounting for 60% of power generation in 2021, Kazakhstan must significantly invest in the plethora of renewable energy resources at their disposal. To attain Carbon Neutrality by 2060 and meet the expected increase in electricity demand, Kazakhstan must increase its renewable energy generation by an estimated factor of 140 (roughly 500 TWh).

Energy tariffs, not reflecting the real cost of energy, constitute a barrier to scaling renewable energy technologies. Policies promoting modern price mechanisms must be introduced to incentivize investments whilst concurrently not burdening the livelihoods of the population. Energy system flexibility also remains a major barrier towards enabling energy system resilience and decarbonization, yet integrated energy systems and electricity interconnectivity can constitute viable solutions.

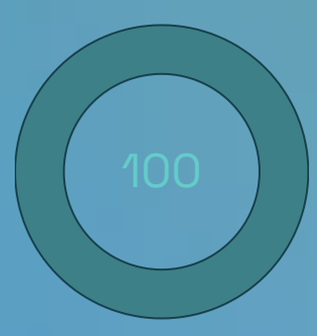
Advancements in energy efficiency are imperative, notably in the residential and industrial sectors which are concurrently the most energy and carbon intensive sectors in Kazakhstan contributing to about 80% of total CO2 emissions. By applying modern energy efficiency standards in the buildings sector, Kazakhstan can improve its energy efficiency by at least 30%. Primarily powered by coal, steel and iron manufacturing account for over one third of total industry sector energy consumption. There is a potential to decarbonize this hard-to-abate sector through CCUS and hydrogen.

Although the Kazakh economy relies on fuel exports, which accounted for 15.4% of Kazakhstan's GDP in 2021, the energy transition is shaping new long-term opportunities for the export of hydrogen and critical raw materials.

Tracking SDG 7

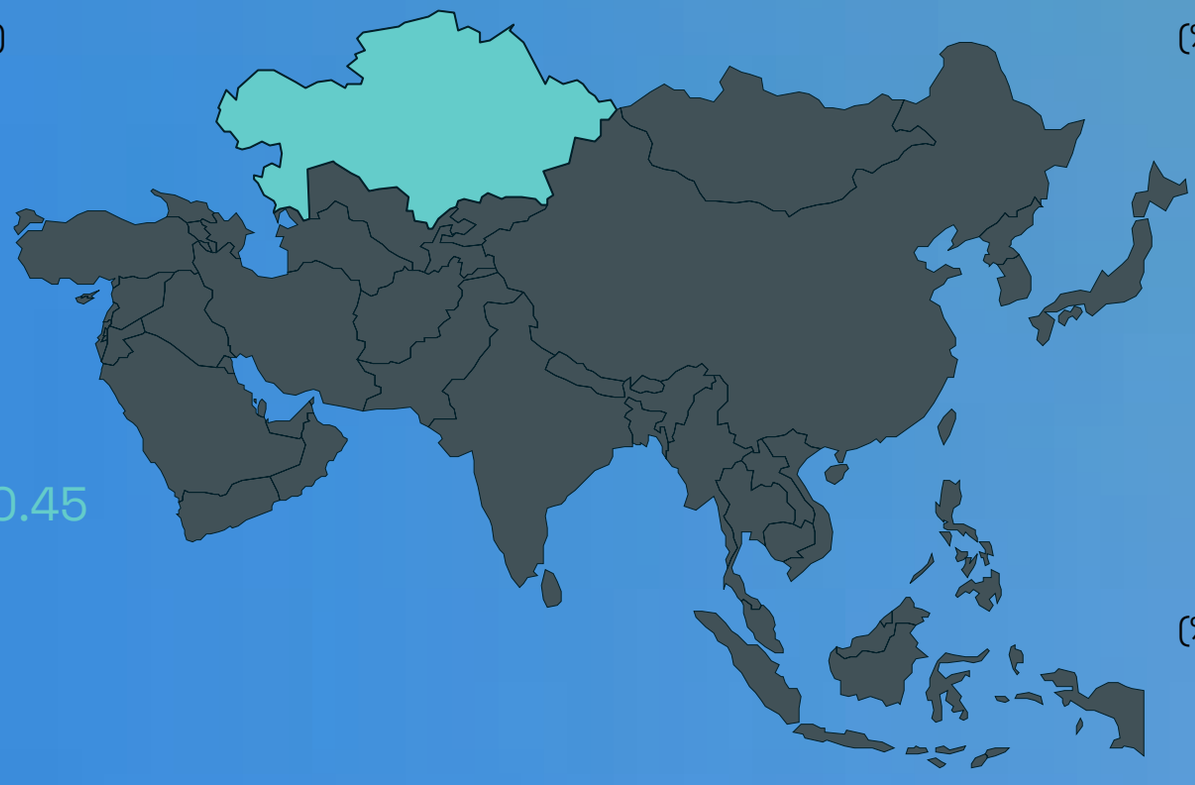
Ensure access to affordable, reliable, sustainable, and modern energy for all

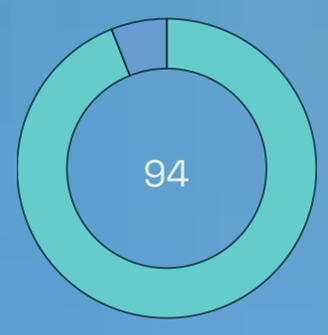
Renewable energy
(% of population with access Year: 2021)



Access electricity
(% of population with access Year: 2021)

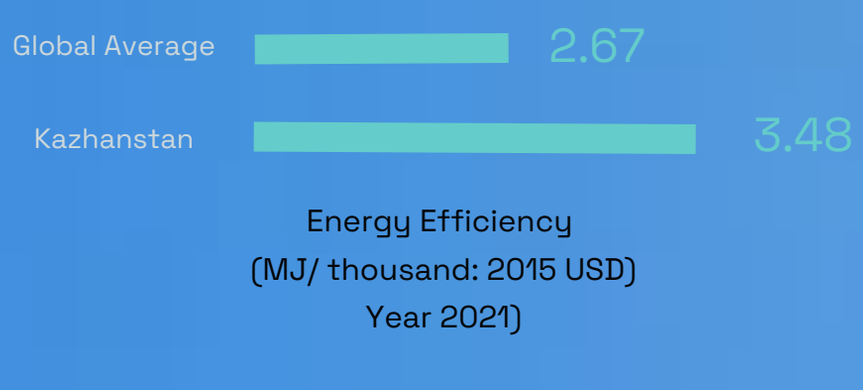
Carbon Intensity of GDP:
(Kg CO2/2015 USD$)





Access to clean cooking
(% of population with access Year: 2021)

Energy Sector Methane Emissions
(Thousand Metric Tons of CO 2 Equivalent: Year 2020)



Energy Efficiency
(MJ/ thousand: 2015 USD)
Year 2021)

Renewable Electricity
(% Total of Energy Supply: Year 2020)

Environmental and Energy Overview

Key Takeaways:

1. Kazakhstan is the largest emitter in the region, with a CO2 intensity of GDP 70% higher than the global average.
2. Electricity and heat generation contribute to over half of CO2 emissions.
3. Fuel exports accounted for 15.4% of Kazakhstan's GDP in 2021.
4. According to the IEA, in 2021, the Kazakh Energy Sector accounted for an estimated 85% of the country's total GHG emissions.

Paris Agreement Targets

Unconditional Target: 15% reduction in GHG emissions by 2030, relative to 1990 base emissions level.
Conditional Target: 25% reduction in GHG emissions by 2030, relative to 1990 base emissions level, subject to:

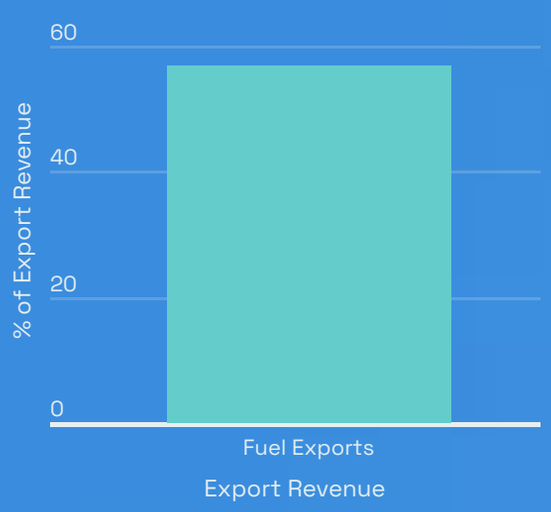
- International investment & grant assistance
- International technology transfer
- Co-financing & participation in international R&D projects
- Developments in low-carbon technology & local expertise

Energy Infrastructure

- Kazakhstan's energy export routes via pipelines play a crucial role in its economic development and environmental impact.

Economic Impact

Fuel exports contribute significantly to Kazakhstan's GDP, accounting for **15.4% in 2021.**



Carbon Neutrality Goal

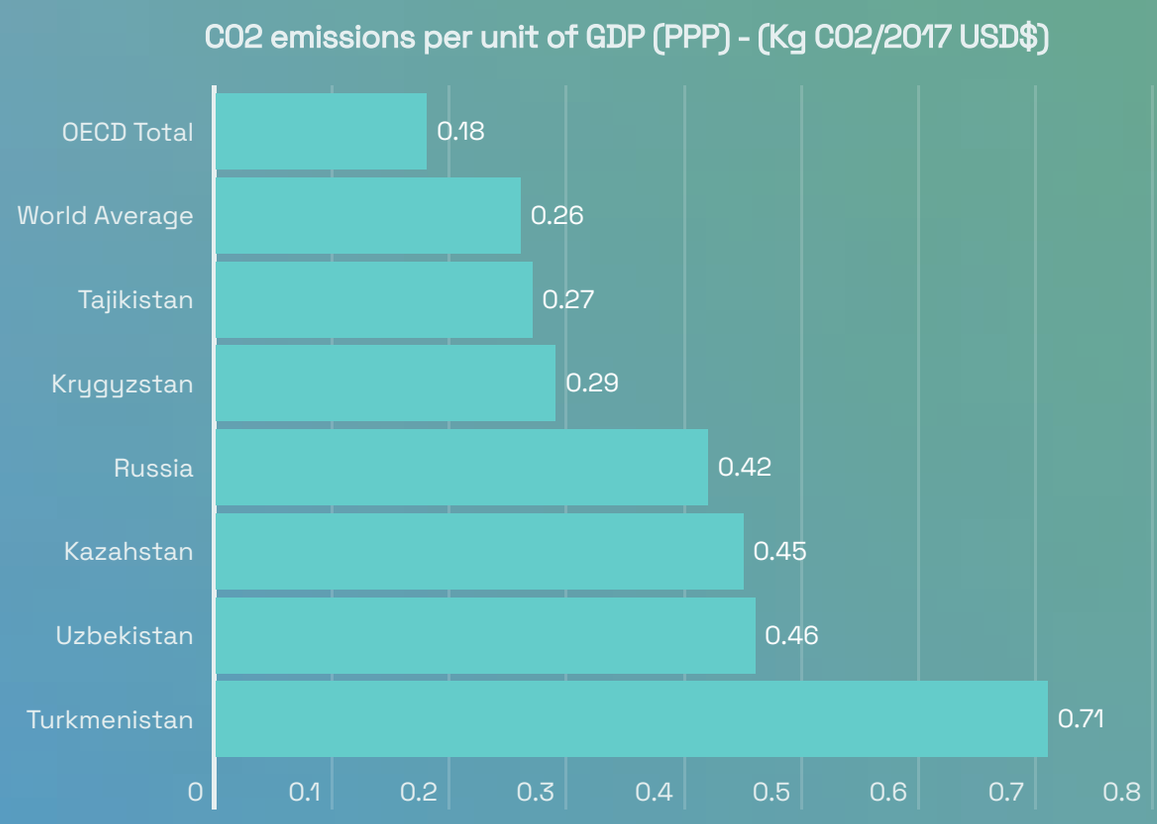
Kazakhstan targets carbon neutrality by 2060, aligning with global sustainability efforts.

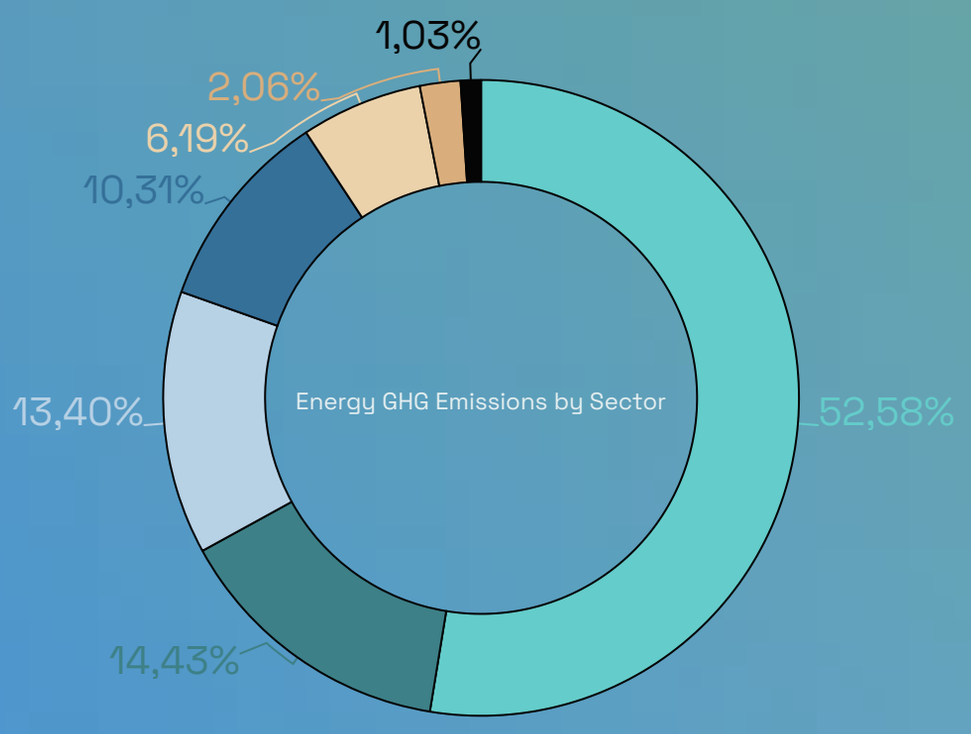
Pollution

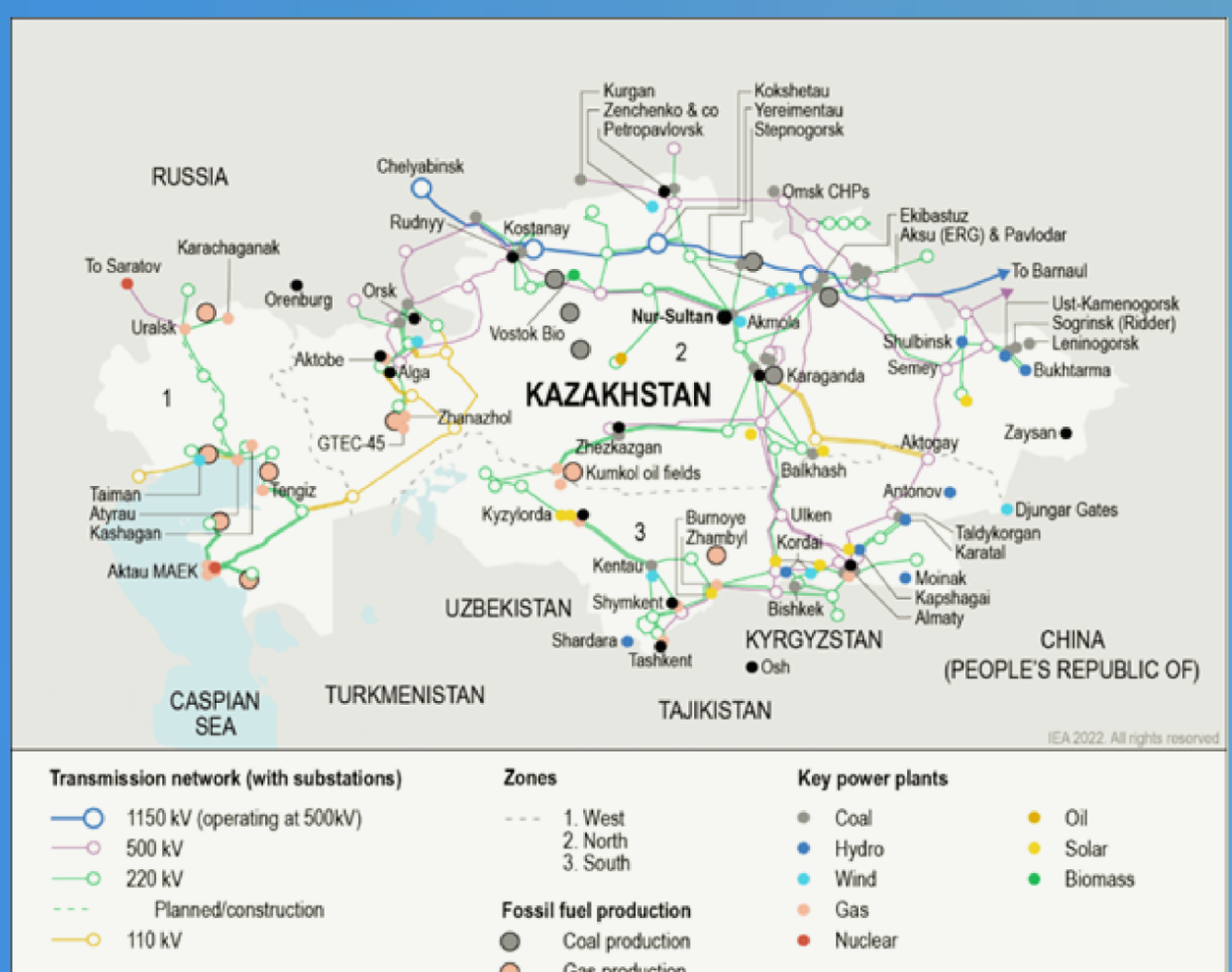
- PM2.5 Air pollution exceeded WHO guideline in 2017 (87.15%).
- High mortality rate attributed to air pollution in 2019 (83.4 per 100,000 population).
- Methane Emissions in Energy Sector (thousand metric tons of CO2 Equivalent) 46,865.7

Net Energy Exports

Kazakhstan is a major energy surplus nation with net energy exports at **57.4%** of total production.







- Kazakhstan is the second energy surplus nation in Eurasia, following Russia.
- Net energy exports in 2021 constituted 57.4% of total energy production.
- Important export routes include Soviet-era Russian pipelines, Caspian Pipeline Consortium, Baku-Tbilisi- Ceyhan oil pipeline, theKazahstan-China oil pipeline, and Central Asia-China natural gas pipeline.

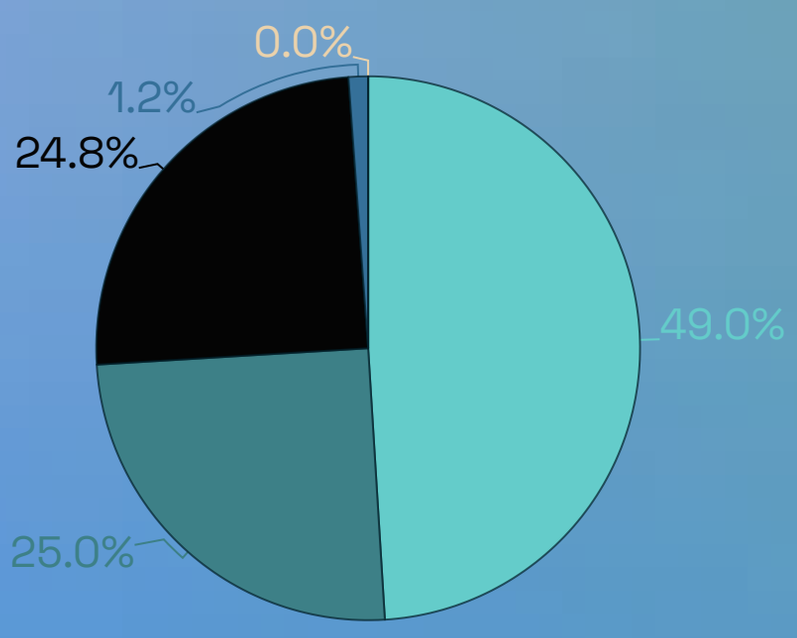
Key Takeaways:

1. Fossil fuels dominate the energy mix: Renewable energy accounts for only 1.6% of Kazakhstan's total energy supply, whilst coal constitutes almost 50% of the share.
2. Kazakhstan must scale low carbon deep electrification across all sectors, currently coal accounts for roughly 60% of power generation.
3. Over the next decade, the demand for electricity is expected to increase by 57%.
4. Kazakhstan faces the challenge of balancing domestic energy consumption with export goals, especially in the context of increasing electricity demand and transitioning towards a lower carbon footprint.

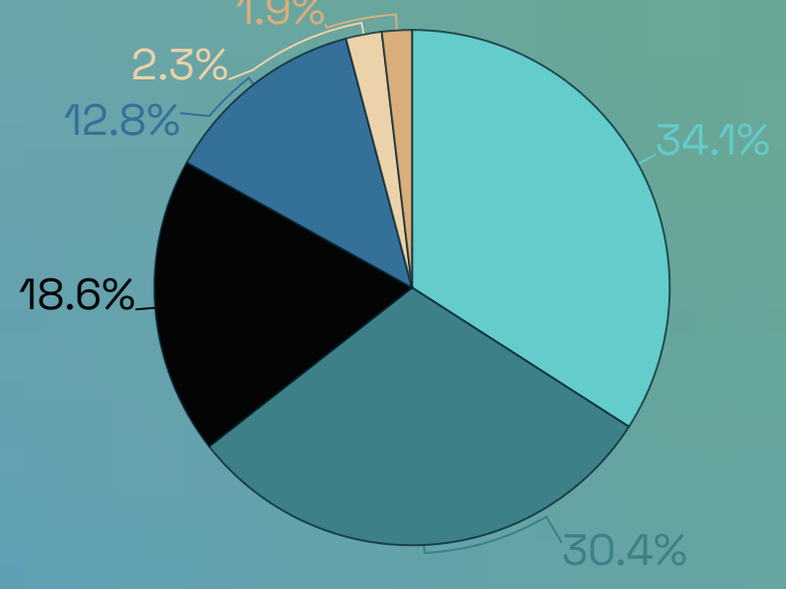
Current

Energy mix

Energy Supply (% Total Energy Supply) (GWh)



Total Energy Consumption by Sector (% Total Energy Supply)



Coal

- Coal Reserves: 33.7 Bt (2.4% of the global total)
- Export (2020): 29 Mt, 86% to Russia with the remaining to other former soviet countries, Europe and China (1%).
- Production: 103.3 Mt in 2020, expected to decrease by 1.5% annually until 2050.
- Consumption by Sector, 2021: Industry: 48.9% (185,961 TJ); Residential: 41.5% (157,994 TJ); Commercial and Public Services: 8.2% (31,259 TJ).

Oil

- Oil Reserves: 30 billion barrels of proven reserves (3.9 billion tones), 12th largest in the world.
- Export: 75% of oil is exported (2,843,119.0 TJ), the majority of which passes through the Caspian Pipeline Consortium (CPC) pipeline.

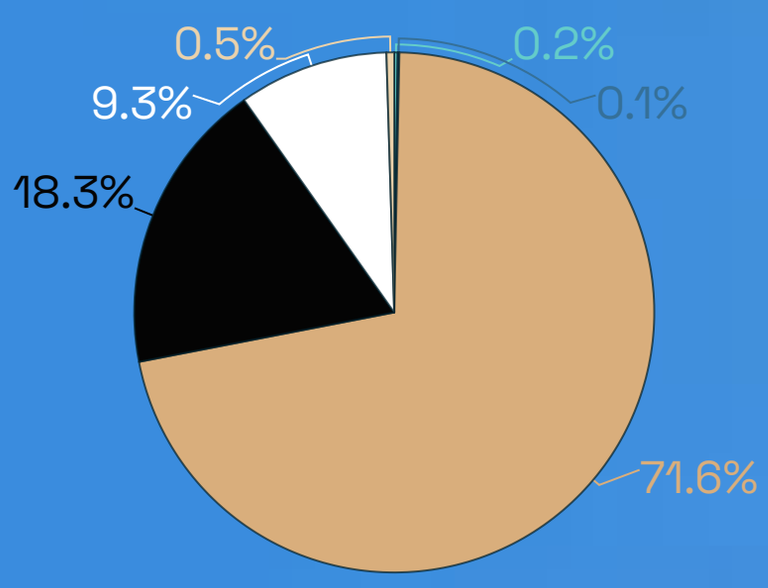
Gas

- Total Proven Gas Reserves: 2.3 trillion cubic meters in 2020, 1.2% of global production.
- Gas Exports: 28.1% of total gas production in 2021 (300.295.0 TJ), accounting for 9% of all energy exports.
- Domestic Demand: Grown by 90% in the last decade, household connection to the centralized gas supply has grown from 30% in 2013 to 55% in 2021.
- Future Production: Limited by insufficient commercial incentives to 36 bcm in 2030, subsequently decreasing to 30 bcm/year by 2050.
- Challenge: Balancing domestic gas consumption and export goals.

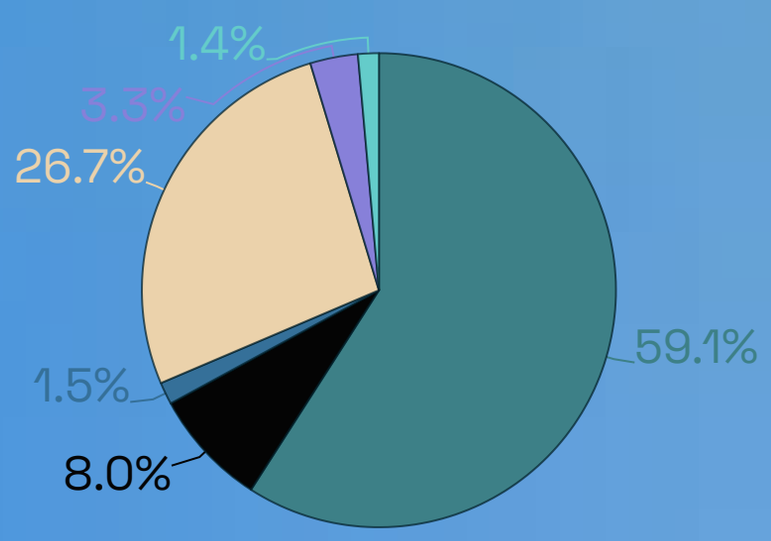
Hydogen

- Hydrogen Development: Creation of Green Hydrogen Alliance aimed at developing hydrogen production .
- Domestic Consumption: In hard to abate sectors, I.e., transport & industry (steel production).
- Export: To foreign markets, where hydrogen demand is expected to increase significantly amidst decarbonization efforts.
- UNECE's report on Sustainable Hydrogen Production Pathways highlights key opportunities and pathways in Kazakhstan for Hydrogen production and export (i.e., using existing gas infrastructure).

Electricity Consumption by Sector (% of Total Consumption) (GWh)



Electricity Generation by Source (% Total Electricity Generation)



Anticipated Maximum Electrcity Load

Expected to reach 22,886 MW by 2029, a 39% increase compared to 16,459 MW in 2022.

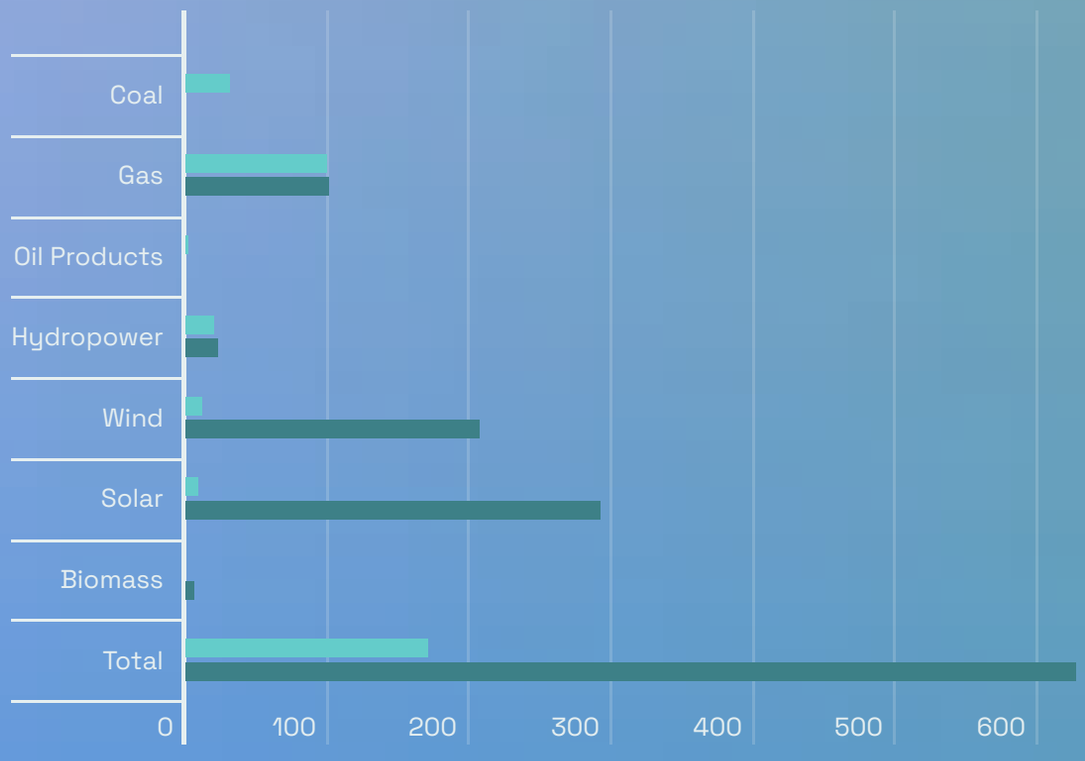
Forcasted Electrcity Demand

153 TWh by 2035, a 57% increase compared to 86.9 TWh in 2021 .

Key Takeaways:

1. To attain Carbon Neutrality by 2060 and meet the expected increase in electricity demand, Kazakhstan must increase its Renewable energy generation by an estimated factor of 140 (roughly 500 TWh).
2. Subsidized energy tariffs, not reflecting the real cost of energy, constitute a barrier to scaling renewable energy and storage.

Kazakhstan's Projected Electricity Supply (TWh/Year) According to the Doctrine of Achieving Carbon Neutrality (Left: Baseline Scenario, Right: Carbon Neutrality Scenario)



This graph excludes nuclear energy, yet in 2022 the ministry of energy agreed to introduce a 2.4 GW nuclear energy reactor to the energy balance for 2035.

Integrating Lifecycle Assessments of RET:

As per UNECE's LCA, all energy technology assessments must incorporate environmental, social and governance implications along the entirety of the technology's value chain.

01

Investment Barrier

Low energy tariffs create barriers to investment and effective policy design across many sectors, notably on the development of gas, renewables as well as heating and electricity infrastructure modernization.

02

Tariff Cost Coverage

Tariffs for conventional power producers are amortized and reflect short-term marginal costs of production.
Consequently, they do not consider externalities, such as GHG emissions or pollution.
Additionally, tariffs do not fully account for maintenance and replacement costs, consequently disincentivizing efforts to increase efficiency and modernize aging infrastructure.

03

Solution

Kazakhstan began using auctions to attract investments in renewable energy and new flexible generating capacity, such as large gas-fired, nuclear and hydropower projects.

Just Transition

Modern energy pricing mechanisms and policies are required to incentives investment into the energy sector whilst simultaneously not burdening the livelihoods of the Kazakh population.

Storage

Energy storage can deliver system flexibility.
No incentives for RES projects to include storage:

- PPAs absolve producers of any financial responsibility for balancing energy generation.
- Storage would significantly raise the costs of RES and energy tariffs substantially above current ones.

Low-carbon Energy

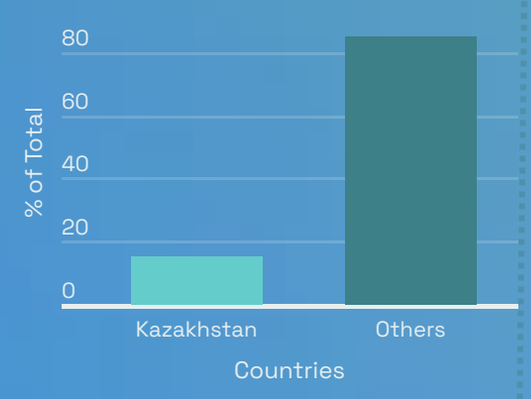
Technologies Potential

Hydropower

- Technical Feasibility: 62 billion kWh/year.
- Development Areas: Irtysh River basin (North), Ili River basin (southeast), and the Syrdary, Tas, and Chus River basins (south).
- Flexible Generation: Possible depending on water irrigation schedules.

Carbon Capture & Storage

- Carbon Neutrality Doctrine: CCS will have to sequester 50 Mt of CO2 annually between 2040-2060 to offset gas & coal emissions.
- CCS Locations: 6 sedimentary basins: Preacaspian, Mangyshlak, Ustyurt, South Torgay, Chu-Sarysu and Zaysan basins.
- CCS Potential of the 6 Basins: 204 Mt, 610 Mt, and 403 Gt in oil reservoirs, gas reservoirs and saline aquifers, respectively.



Wind

- Wind Speed: 4-5 m/s at a height of 30m in 50% of the country.
- Wind Energy Potential: Technical feasibility of 920 billion kWh/year, 10 times greater than current demand.
- Levelized cost of Energy: 4.87 USc/kWh

Nuclear

- Uranium: Possess the second largest recoverable uranium reserves, 906 800 tons, representing roughly 15% of the global aggregate.
- Baseload Energy: Notable opportunity for the provision of low-carbon baseload energy.Developments: No operational power plants to date, yet, Kazakhstan has began selecting sites and approving preliminary supplier shortlists.

Geothermal

- Estimated Energy Potential: 97 billion tons of oil equivalent (toe), comparable to Kazakhstan's oil and gas resources

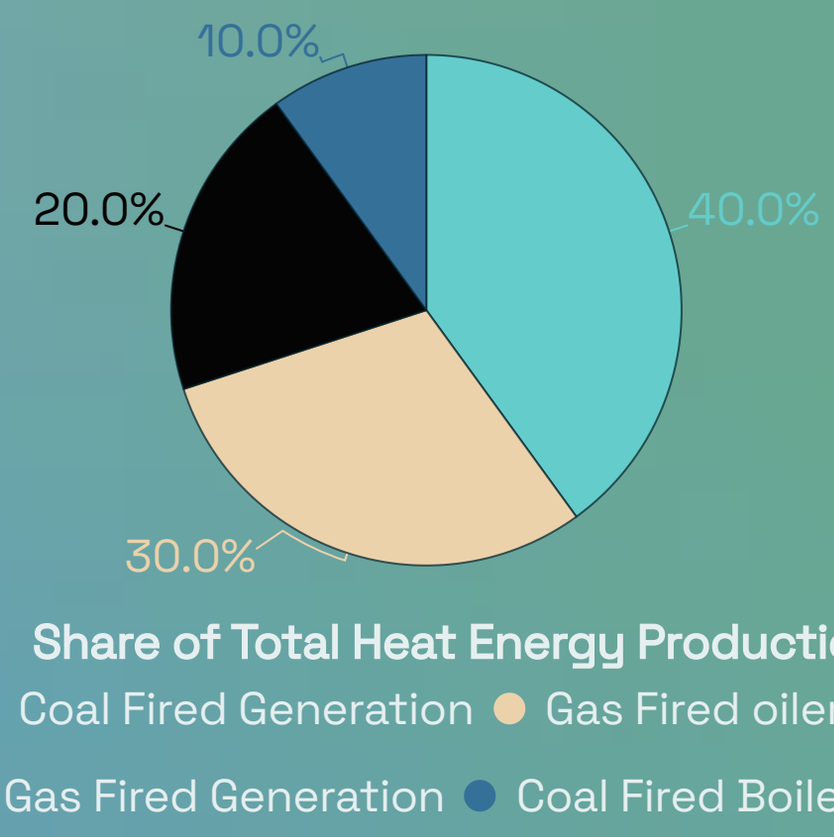
Solar

- Solar Radiation: 2,200-3,000/8,760, annually.Annual Solar Energy Potential:
- Central & Southern KZ: 1,300 - 1,800 kWh/m 2
- Western & Northern KZ: 1,000-15,000 kWh/m 2
- Levelized cost of Energy: 5.7 USc/kWh.

Decarbonizing Buildings, Industry and Transport Sectors

Key Takeaways:

1. Advancements in energy efficiency are imperative, notably in the residential and industrial sectors which are concurrently the most energy and carbon intensive sectors in Kazakhstan contributing to about 80% of the total CO2 emissions.
2. By applying modern standards for energy efficiency in the buildings sector, Kazakhstan can improve its energy efficiencies by at least 30%.
3. Steel and iron manufacturing account for over one third of total industry sector energy consumption today primarily powered by coal. There is a potential to decarbonize this hard-to-abate sector through CCUS and hydrogen.



Heating

Kazakhstan's heating network, covering 12,000km, is carbon intensive.

The heating network is ageing, inefficient and in need of repair and modernization.
Heating tariffs: kept low, below the costs of production, for social reasons, and hence disincentivize investment in the modernization of the grid.

Losses are reportedly as high as 30% and the average efficiency of district heating systems in Kazakhstan is reportedly 58% (MoE, 2021).

Heating represents roughly 60% of household energy use, improving efficiency in Kazakhstan's heating network can substantially reduce household energy consumption and carbon intensity.

Buildings

Most Buildings in Kazakhstan do not meet modern standards for energy efficiency, with an estimated 70% of buildings losing up to 30% of thermal energy they consume.

Average energy performance levels are one-third of those in northern Europe.

Consequently, the IEA claims that the energy saving potential of retrofitting Kazakhstan's buildings is estimated to be, on average, above 50 %.

Inefficiency in building legislation

Current legislation prescribes minimum energy performance levels, specified in building passports, for new buildings and retrofits.

Yet, building passports are granted during the design stage without follow-ups on actual energy consumption.
Thus, energy efficiency in the construction and operation of buildings is often neglected and suboptimal.

The UNECE Action Plan for Energy-efficient Housing in the UNECE Region provides a framework to overcome barriers to energy efficiency investments and to move progressively toward a low energy and carbon neutral housing sector.

Industry

Kazakhstan's industry heavily relies on coal and electricity. Both energy sources are mainly used in the "iron and steel" and "non-ferrous metals" sub-sectors. The production of iron and steel in Kazakhstan accounts for about 34% of industry's overall final energy consumption.

Steel and iron production is energy intensive and hard to decarbonize. Innovative, low- and zero-carbon technologies, such as CCUS and hydrogen, can help decarbonize these hard-to-abate sectors.

CCCUS can significantly contribution to steel production. Retrofitting blast furnaces and basic oxygen furnaces with CCS can be a mid-term solution until DRI production options with zero-carbon hydrogen become more cost-competitive. Hydrogen is considered the most promising technology to decarbonize the steel sector. It can be used to generate heat and as a reduction agent replacing coking coal to remove oxygen from iron ore, leaving water as a by-product instead of CO2.

Steel manufacturing will play a pivotal role in the transition as it is a component of electric vehicles, wind turbines, infrastructure and manufacturing processes. This sector implies an opportunity for the future exports of carbon-neutral materials.

Energy System Flexibility

Key Takeaways:

1. Energy system flexibility remains a major barrier towards enabling energy system resilience and decarbonization, yet integrated energy systems and electricity interconnectivity can constitute viable solutions.

Flexbility concerns

Kazakhstan lacks flexible generating capacity. Its baseload capacity is dominated by large coal-fired power plants which cannot be rapidly powered up or down in response to large, unexpected fluctuations in demand as well as the intermittent nature of renewables. The shortage of flexible capacity is likely to become an increasing challenge as more intermittent renewables are added to the system.

Electricity Interconnectivity

Kazakhstan currently relies on parallel operations with the Russian power system, to cover balances and maintain frequency stability. Net electricity imports from Russia in 2021 amounted to 461 GWh in 2021.Power imports occur during peak demand in Kazakhstan, hence, import prices are considerably higher than export prices.

As a member of the EAEU, Kazakhstan is involved in establishing the Common Electricity Market, which the EAEU plans to launch in 2025.

Integrated energy systems

Kazakhstan's energy systems, constructed during the soviet era, are largely interconnected with neighboring Russia, Uzbekistan, Tajikistan and Kyrgyzstan as well as China in the case of oil & gas.

Interconnectivity resilience

The planned grid construction in Kazakhstan, Uzbekistan, Kyrgyzstan, Tajikistan, Turkmenistan and Afghanistan is aimed at increasing reliability, power output and export (or transit) of electricity to neighboring countries. This unified energy system could help balance electricity baseloads and provide baseload flexibility by transferring electricity from one system to the other during peak demand, redistributing power from surplus areas to areas facing power shortages, i.e during peak demand. .

Transmission Challenge

The average depreciation rate for regional networks is reportedly 66% and requires modernization. Transmission losses from high-voltage KEGOC networks amounted to 5.6% in 2021. Hence, grid refurbishment is urgent and significantly important for interconnectivity with neighboring countries to mitigate the risks of interregional power blackouts, such as those which affected the Kazakh, Kyrgyz and Uzbek systems in 2022.

UNECE Contribution

UNECE's report on Energy Connectivity in Central Asia showcases an inventory of existing national energy systems and pathways for further developing interconnectivity to build energy system resilience.

Map of regional electricity interconnection

Source: USAID (2015), Central Asia Electric Grid.

Critical Raw Materials

Key Takeaways:

1. Kazakhstan possesses 29/30 critical raw materials required for enabling the energy transition.

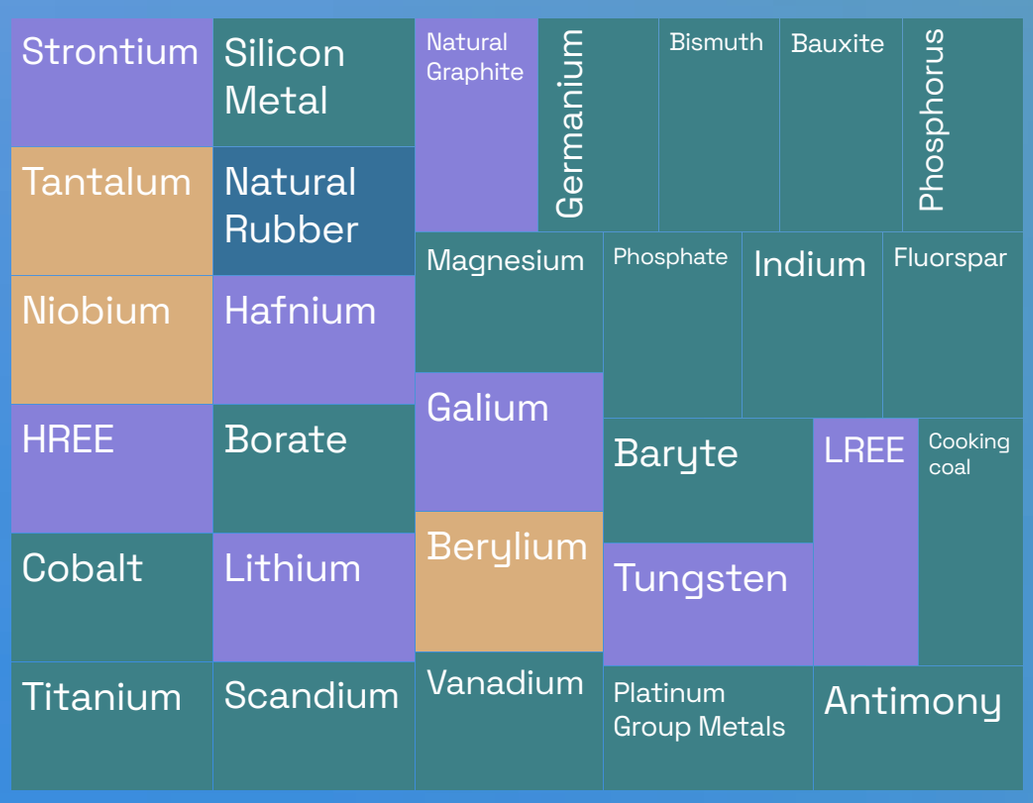
CRM Importance

Currently many countries are considering objectives to increase their self-sufficiency on critical raw materials (CRMs) which are prerequisites for a just energy transition, with renewable energy national targets of up to 30%. Many of these CRMs are now essential components in high-tech sectors. These components include rare earth metals, as well as other metals like lithium, indium, tellurium, gallium, and platinum group elements.

CRM Reserves

- Kazakhstan Boasts 29/30 critical raw materials.
- Data on CRM reserves dates to research conducted during the soviet era and is considered unreliable.
- The collection of reliable, comprehensive & accurate data is essential to evaluate CRM opportunities in Kazakhstan.

Kazakhstan's CRM Portfolio



Kazakhstan's Proven Reserves of Raw Material's Critical to the Manufacture of Renewable Energy technologies

Critical Material	% of Proven Global Reserves	Uses (as Components)
Chromium (Ore & Concentrate)	30.7	Wind Turbines
Manganese	27.6	Wind Turbines, EV's, Batteries/Storage
Lead	11.9	Solar Panels, Wind Turbines, EVs, Batteries/Storage
Zinc	8.6	Solar Panels & Wind Turbines
Cobalt	5.2	Wind Turbines
Copper	5.1	Solar Panels, Wind Turbines, EVs, Batteries/Storage
Molybdenum	4.0	Wind Turbines
Aluminum/Bauxite	1.2	Solar Panels, Wind Turbines, EVs, Batteries/Storage
Iron Ore	1.2	Solar Panels, Wind Turbines, EVs, Batteries/Storage
Nickel	1.1	Solar Panels, EV's, Batteries/Storage
Titanium	1.0	EV's, Batteries/Storage

Opportunities

CRMs must be harnessed to ensure stable future procurement of resources critical to the energy transition.
Kazakhstan can become a global leader in the exportation of CRMs, consequently diversifying the nature of its exports, reducing fuel trade dependence & risk, and providing new long-term streams of revenue.

Indeed in 2020, the government of Kazakhstan announced that lithium mining will be prioritized over the next 5 years to ride the wave of global demand for EVs.

Mr. Aitkulov, the head of mining projects at Kazakhstan's main investment agency, Kazakh Invest, noted: "lithium can soon become a second oil for Kazakhstan."

According to IEA: "today's supply and investment plans for many critical minerals fall well short of what is needed to support an accelerated deployment of solar panels, wind turbines and electric vehicles/batteries."

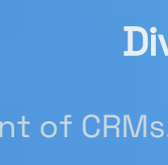
Kazakhstan's vast reserves of such materials, could bridge the gap if adequate policy is introduced.

Coal Mine and Just transition

Coal currently significantly contributes to Kazakhstan's energy mix. Nonetheless, the government has expressed its intent to decrease coal production by 1.5% annually until 2050. To ensure a just transition in energy and safeguard the livelihoods of those involved in Kazakhstan's coal industry, alternative livelihood avenues must be established. Given that many coal mines in Kazakhstan also contain substantial quantities of Critical Raw Materials (CRMs), repurposing these mines for CRM extraction could protect the interests of coal industry stakeholders. Furthermore, as the export of CRMs holds greater economic potential compared to coal, reutilizing CRM-rich coal mines could stimulate increased economic growth.

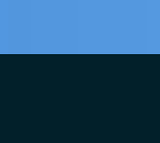
The United Nations Economic Commission for Europe's Group of Experts on Coal Mine Methane and Just Transition stands ready to assist Kazakhstan in reducing and managing methane emissions from active, closed, and abandoned coal mines. They can also aid in repurposing existing coal mines to exploit their CRM resources while providing support for mine closures.

Policy options for Securing Access to CRMs in Kazahstan

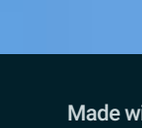


Promoting Circular Economy

Fostering Innovation and Cooperation



Strengthening Governance and Transparency



Increasing Investment

Diversifying Primary Sources

Frameworks for CRM Management

UNFC and UNRMS play crucial roles in promoting the sustainable and responsible development of CRMs. Considering the intricate interplay between the production, utilization, and recycling of CRMs and their impact on society, the environment, and the economy, comprehensive systems like UNFC and UNRMS are imperative for effective and integrated natural resource management.

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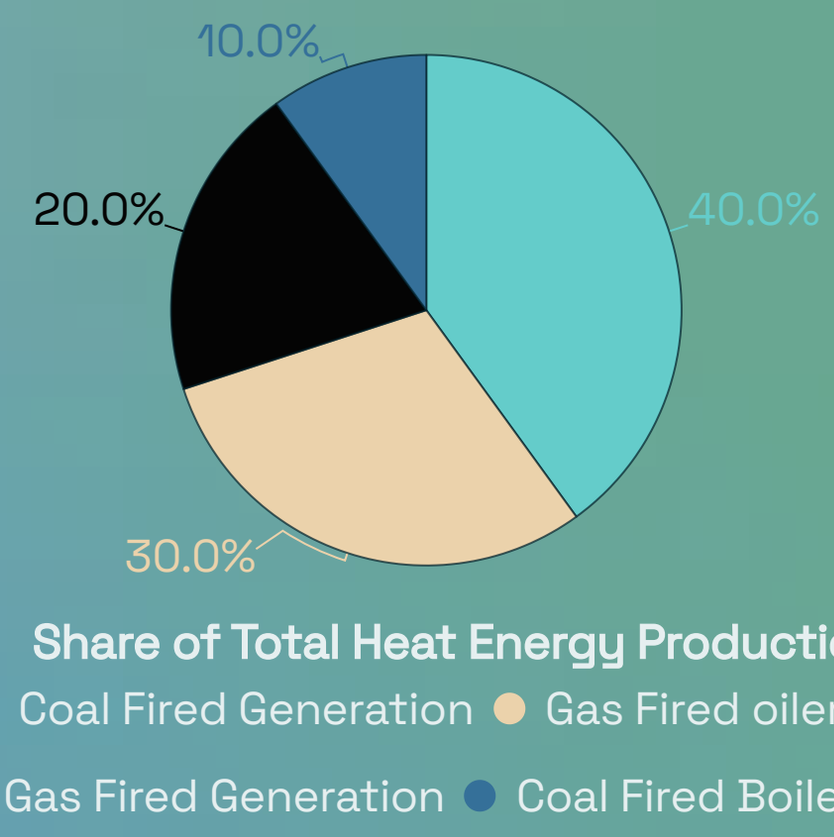

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Most Buildings in Kazakhstan do not meet modern standards for energy efficiency, with an estimated 70% of buildings losing up to 30% of thermal energy they consume.

Average energy performance levels are one-third of those in northern Europe.

Consequently, the IEA claims that the energy saving potential of retrofitting Kazakhstan's buildings is estimated to be, on average, above 50 %.

Inefficiency in building legislation

Current legislation prescribes minimum energy performance levels, specified in building passports, for new buildings and retrofits.

Yet, building passports are granted during the design stage without follow-ups on actual energy consumption.
Thus, energy efficiency in the construction and operation of buildings is often neglected and suboptimal.

The UNECE Action Plan for Energy-efficient Housing in the UNECE Region provides a framework to overcome barriers to energy efficiency investments and to move progressively toward a low energy and carbon neutral housing sector.

Industry

Kazakhstan's industry heavily relies on coal and electricity. Both energy sources are mainly used in the "iron and steel" and "non-ferrous metals" sub-sectors. The production of iron and steel in Kazakhstan accounts for about 34% of industry's overall final energy consumption.

Steel and iron production is energy intensive and hard to decarbonize. Innovative, low- and zero-carbon technologies, such as CCUS and hydrogen, can help decarbonize these hard-to-abate sectors.

CCCUS can significantly contribution to steel production. Retrofitting blast furnaces and basic oxygen furnaces with CCS can be a mid-term solution until DRI production options with zero-carbon hydrogen become more cost-competitive. Hydrogen is considered the most promising technology to decarbonize the steel sector. It can be used to generate heat and as a reduction agent replacing coking coal to remove oxygen from iron ore, leaving water as a by-product instead of CO2.

Steel manufacturing will play a pivotal role in the transition as it is a component of electric vehicles, wind turbines, infrastructure and manufacturing processes. This sector implies an opportunity for the future exports of carbon-neutral materials.

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