ADB

Technical Assistance Consultant's Report

Project Number: TA-9308 REG
October 2020

Kazakhstan: TA-9308 REG: Promoting Low-Carbon Development in Central Asia Regional Economic Cooperation Program Cities

Financed by the Clean Energy Fund

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For Asian Development Bank

Asian Development Bank

CURRENCY EQUIVALENTS

(as of April 1, 2020)

Currency Unit Kazakh Tenge (KZT)
USD 1.00 = 420 KZT
KZT 1.00 = 0.00236 USD

ABBREVIATIONS

AC	Alternating Current
AMI	Advanced Metering Infrastructure
BHT	Block Heater Technology
CHP	Combined Heat and Power
CO	Carbon Monoxide (can be lethal at higher concentrations)
CO2	Carbon Dioxide
CPS	Charging Pile Station
Cyl.	Cylinder (engine displacement volume)
EV	Electric Vehicle
JSC	Joint Stock Company
KTZ	Kazakhstan Temir Zholy (National Railway Company)
KZT	Kazakh Tenge
MNE	Ministry of National Economy
MoF	Ministry of Finance
NBK	National Bank of Kazakhstan
NOx	Nitrous Dioxide (NO2) and Nitrous Oxide (NO)
OECD	Organisation for Economic Co-operation and Development
OEM	Original Equipment Manufacturer
PEV	Plug-in Electric Vehicle
PM10	Fine Particles 10 micrometers or less in Air
PM2.5	Fine Particles 2.5 micrometers or less in Air
PPP	Public Private Partnerships
QR	Quick Response (Bar Code for Scanning)
RFID	Radio Frequency Identification
SES	Service Entrance Section
SME	Small and Medium-sized Enterprise
UNECE	United Nations Economic Commission for Europe
USD	United States Dollar
VOC	Volatile Organic Compound

WEIGHTS AND MEASURES

µm	micro meter
g	gram
Gg	gigagram
GWh	gigawatt-hour
ha	hectare
kg	kilogram
km	kilometre
km2	square kilometre
kW	kilowatt
kWh	kilowatt-hour
l	litre
m	metre
m2	square metre
m3	cubic metre
MW	megawatt
pkm	passenger kilometre
ppm	parts per million
t	tonne (1,000 kg)
TWh	terawatt-hour

NOTE(S)

(i) The fiscal year (FY) of Republic of Kazakhstan ends on December 31.

(ii) In this report, "$" refers to United States dollars

CONTENTS

EXHIBITS

I. EXECUTIVE SUMMARY

A. ADB Kazakhstan Block Heater Pilot Demonstration

ADB aims to promote system thinking, synergy creation among various sectors like transport, energy, and others while ensuring cities are more livable and resilient. In 2018 the Nur-Sultan Akimat (Mayor's Office) confirmed its participation in the Regional Technical Assistance on Low-Carbon Development in CAREC. Three cities in Hunan Province of the People's Republic of China and Ulaanbaatar in Mongolia also joined this initiative. Almaty and Shymkent in Kazakhstan expressed a strong interest and are willing to join this process and requested ADB support.

This TA will help the cities:

- To develop roadmap for low-carbon economic growth,
- Improve air quality for citizens especially those with respiratory conditions, seniors and youth.
- Reduce carbon emissions and improve environmental conditions
- Strengthen institutional capacity to ensure prosperous, inclusive, and sustainable economic development.

Lessons learned from this block heater pilot will be shared with Nur-Sultan and other stakeholders. After the pilot demonstration there can be many benefits to the economy including activities related to manufacturing, installation and services, engineering and construction and smart city infrastructure.

1. Block Heater Technology

An engine block heater warms the parked car engine during cold winter months so that engine idling is not required. The block heater uses a small heating element (like an electric kettle) to heat the engine when plugged into an external electric plug outlet (electric pile). The optional cabin heater can be used to warm the vehicle and defrost the windows on cold days.

- A single typical automobile with a 2.5 litre gasoline engine idling for 60 minutes per day during a 200-day winter season in Nur-Sultan, Kazakhstan is estimated to consume about 646 liters of fuel.
- Installing a block heater and cabin heater cost between $100-250USD.
- Depending on factors like fuel prices, local winter temperatures and driving habits, the return on this investment (simple payback) is typically between 1-3 years.

There are Three (3) Main Block Heater Technology Components:

1. The engine is heated with an engine block heater. This is a small electric heating device installed by a trained mechanic or by the automobile manufacturer in the factory. This device warms the coolant, which in turn warms the engine block and lubricants. The engine will start more easily and reach its proper operating temperature faster. Power consumption is less than a small electric kettle or coffee maker.

2. The interior of the car can also be heated with an electric fan heater. This will not only defrost the inside of the windows, but also provide warmth and comfort to the occupants on entering the vehicle. Power consumption is about the same as an electric hair dryer.

3. Both the block heater and interior heater are supplied with power from an external electric plug outlet. There can be specialized electric outlet with times programmed to activate the block in accordance with the owner's schedule.

2. ADB's Kazakhstan Pilot Demonstration Project

ADB received commitment from Nur-Sultan Akimat and many stakeholders for implementation. Through competitive process, ADB selected block heater components from CALIX (Sweden) and DEFA (Finland). ADB organized training session for local mechanics to install the components. The electrical outlets are supplied by FIBOX (Finland) and local electrical engineers and construction companies are building the infrastructure. ADB also met with Embassy of Finland to Kazakhstan to spur future business opportunities, joint ventures and technology transfer for Finnish and regional companies to local Kazakh entities.

As shown in Exhibit 1, ADB developed a spreadsheet calculator to help decision makers, vehicle fleet and individual owners evaluate the economic and environmental benefits of block heater technology. This calculator estimates the economic payback and environmental benefit of using block heater technology for various fuel types, engine sizes, and climate conditions.

Exhibit 1 Screenshot of Block Heater Benefit Calculator

Version 2.0 - Engine Block Heater Benefit Calculator for ADB Kazakhstan Project
Updated July 2020

Data Entry and Assumptions		
Winter Outdoor Temperature Range (°C)	-20 °C to -10 °C	elect from Dropdown List
Fuel Type (Gasoline or Diesel?)	Gasoline	<Select either Diesel or Gasoline
Engine Capacity (liters)	1.5 to 2.0 L, 4 Cyl.	<Select from Dropdown List
Rated Fuel Consumption (litres per km)	10	<Select from Dropdown List (most automobiles are about 10 km per liter in City Driving)
Daily Engine Idle Time (minutes)	60	<Use Default or Modify with Whole Number
Number of Winter Days Used (Days)	200	<Use Default or Modify with Whole Number (between 30 and 220 days per year)
Gasoline/Diesel Price (KZT/liter)	145	<Use Default or Modify with Whole Number
Electricity Price (KZT/kWh)	15	<Use Default or Modify with Whole Number
USD to Kazakhstan Tenge (KZT) Exchange	420	<Enter Whole number for USD to KZT Exchange Rate (Approximate 420 KZT per USD July 2020)
USD Cost to Install Block and Interior Heater	200	<Enter Approximate Cost to install Block Heater and Cabin Heater (Typical Range is 100 to 400 USD per installation)

Economic Impact	Current Situation	Block Heater Enabled	Annual Reduction
Vehicle Idiling Seasonal Fuel Consumption	438 litres of fuel	340 kWh Electricity	
Vehicle Idiling Seasonal Fuel Cost	63,510 KZT	5,100 KZT	58,410 KZT

Expected Investment Recovery Period of Block Heater and Cabin Heater Upgrade (Simple Payback)	1.4 years

Greenhouse Gas Emissions Impact	Current Situation	Block Heater Enabled	Annual Reduction
Seasonal Emissions of CO2	1029 kg CO2	263 kg CO2	766 kg CO2

Ground Level Air Pollutants Impact	Current Situation	Block Heater Enabled	Annual Reduction
Carbon Monoxide [CO]	19.2 kg	0.3 kg	18.9 kg
Volatile Hydrocarbons [VOC]	4,380 grams	7 grams	4,373 grams
Nitrous Oxide/Dioxide [NOx]	2,628 grams	95 grams	2,533 grams
Particulate Matter [PM]	219 grams	14 grams	205 grams

In November 2019 (see Exhibit 2), a formal opening ceremony for the Nur-Sultan pilot demonstration project was held attended by dignitaries from Nur-Sultan Akimat, Embassy of Finland to Kazakhstan, and ADB.

Exhibit 2 Project Demonstration Ceremony 16 November 2019

In January 2020, ADB had funded installation of up to 100 engine block heater installations, and 53 electrical Charging Pile Stations (CPS) as shown in Exhibit 3. Participating test automobiles came from Nur-Sultan Akimat (employee-owned), Astana Taxi, and Astana Toyota City. Several potential additional host sites included Nur-Sultan Akimat (City Hall), Nur-Sultan International Airport and car dealerships where the technology can be demonstrated to consumers.

Sites for the charging piles include:

- Astana Toyota City (9),
- Kazakhstan Railroad Authority (4),
- Sary-Ara Akimat (7),
- Mangilik Yel Parking (5)
- Yessil Akimat (6)
- Astana Tower (5)

Exhibit 3 Location of Nur-Sultan Charging Pile Stations

In September 2020, ADB organized a Virtual Business Fair which was attended by local and international participants including diplomats, government agencies, economic development, environmental stakeholders, manufacturers, service providers and supply chain. The themes of the business fair included:

- Session I: Introduction
- Session II: Overview on Promoting Low-Carbon Development in Nur-Sultan and Kazakhstan
- Session III: Future of Technology Transfer
- Session IV: Technology Deployment in Nur-Sultan
- Session V: Localization of Technology in Nur-Sultan
- Session VI: Wrap-Up

For wider dissemination of block heater technology, the Business Fair presentations were posted on the ADB Knowledge Events website:

https://events.development.asia/learning-events/block-heater-technology-business-fair
(Web Link Validated October 2020)

3. Potential Economic and Environmental Impact

There are approximately 350,000 vehicles registered in Nur-Sultan, Kazakhstan. During the cold winter days (as low as -35°C), most citizens often idle their car engines for long periods to warm the engine and interior. This unnecessarily wastes fuel, costs money, causes excess engine wear and tear. In a typical vehicle, every 40 minutes of idling uses 1 liter in wasted fuel and releases 2.3 kg of CO2, a greenhouse gas causing climate change and harmful air pollutants. Nur-Sultan could achieve the reduction of over 220 million liters of fuel, and 430 thousand tons of carbon emissions reduction with block heater technology.

Engine block heater technology is a proven method to save money, improve comfort, reduce pollution and reduce wear and tear on the engine. It also brings about positive health benefits to you, your family, and your community. Consider using this technology in your vehicle to make a positive impact.

The block heater technology also represents a considerable economic opportunity for Kazakhstan and encompasses:

- Block Heater component manufacturing and assembly
- Block Heater infrastructure growth for electrical suppliers
- Installation for automotive dealers
- Reduced operating costs (fuel and maintenance) for fleet vehicles and private automobiles
- Reduction to ground level air pollution and health benefits to citizens

II. KAZAKHSTAN COUNTRY OVERVIEW

A. Geography

Kazakhstan is a landlocked country in Central Asia (see Exhibit 4). It borders the Russian Federation to the north (length of the frontier, 6,846 km), Kyrgyzstan (1,051 km), Uzbekistan (2,203 km) and Turkmenistan (379 km) to the south, the People's Republic of China to the east (1,533 km). With an area of 2,724,902 km2, it is the ninth largest country in the world and the largest of the Central Asian countries. The country's territory stretches 3,000 km from west to east and 1,700 km from north to south.

Exhibit 4 Kazakhstan Map

The country's topography has stark differences. The lowest elevation is located in the southwest, where the Karagiye depression is located 132 meters below sea level. High mountain ranges extend over the eastern and southeastern borders of the country. The highest point, Khan Tingri (6,995 m), is located in the Tianshan Mountains in the far southeast. The Altai Mountains, along the country's eastern border, also have high mountain peaks. The country's topography consists mostly of deserts, plains and mountainous highlands.

Deserts and semi-deserts (such as stones, salt and sandy terrain) cover more than two-thirds of Kazakhstan's area. The largest deserts are the Kyzylkum arid sand and Betpak-Dala clay soil, both of which are located in the southern part of the country. The climate is continental, with hot and dry summers and relatively cold and dry winters. Temperatures vary greatly by region, with the most dramatic differences between deserts and mountains. Southern regions have mild winters and hot summers. The strong cold winds from the north make the winter on the steppes particularly harsh.

1. Population

Kazakhstan's population increased from 17.92 million in 2017 to 18.76 million in 2020. The average population density is 6.89 inhabitants per km2. Most of the population lives in either the east, south-east or central oblasts, while the other oblasts are sparsely populated.

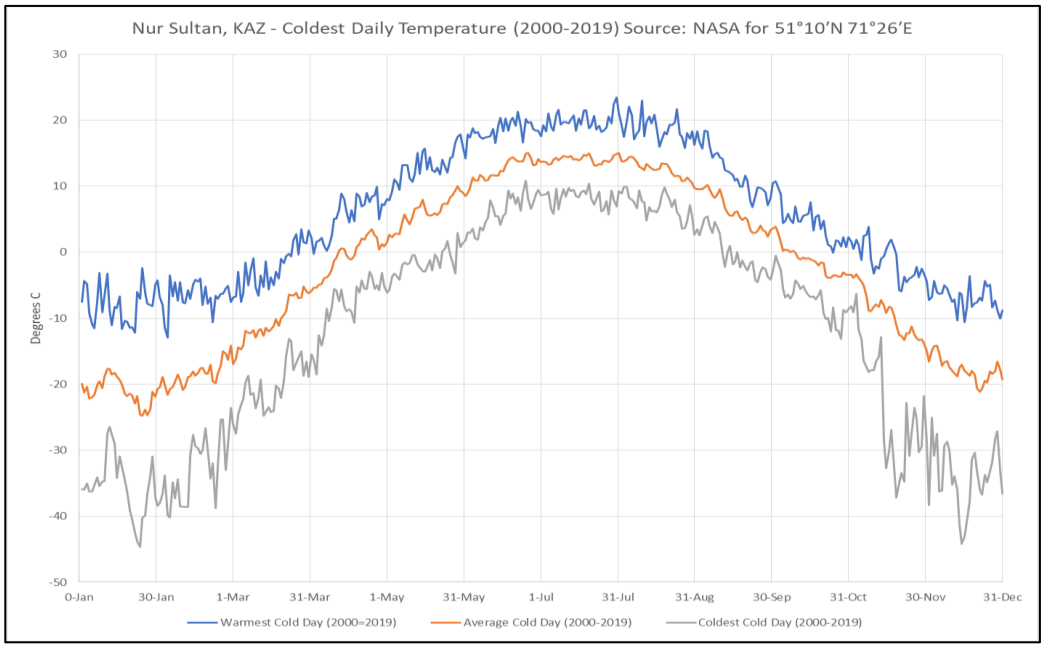
Nur-Sultan, the capital of Kazakhstan is a fast-growing city. It had a population of 649,152 in 2010, and by 2020, the population had grown to 1,136,156, an increase of almost 75 per cent. The former capital, Almaty, with a population of 1,916,822 in 2020, remains an important scientific, cultural and financial center. Other major cities include Shymkent (population 1,038,152 in 2020), a center for heavy industry, including chemical manufacturing and the smelting of lead and zinc.

2. Climate

Depending on the region, the average daily temperature in January ranges from -19 °C to -4 °C and in July from 19° C to 26° C. Extreme summer temperatures can reach 45 ° C and extreme temperatures can drop to -45° C. Annual rainfall levels are generally low, less than 100 mm in deserts and between 250 mm and 350 mm in the steppe. During the winter, most of the country is covered with snow. In the mountains, where the mountain tops are permanently covered with snow, the average precipitation is 1500 mm per year.

Exhibit 5 presents the daily temperature for Nur-Sultan, Kazakhstan which is the main focus for the project. Situated in the northern part of Kazakhstan, Nur-Sultan is subject to bitterly cold winters and is an ideal location for BHT. The coldest cold day is indicated in grey, the warmest cold day in blue, and the average cold day in orange. It can be seen that Nur-Sultan experiences bitterly cold winters with subzero temperatures between mid-August and late-April.

Exhibit 5 Daily Temperature Range for Nur-Sultan between 2000 and 2019



III. KAZAKHSTAN INSTITUTIONAL FRAMEWORK

1. Ministry of Ecology, Geology and Natural Resources

The Ministry of Ecology, Geology and Natural Resources was established on 17 June 2019 as a central government agency responsible for policies, programing and strategy development of the ecology, geology and water sector. The Ministry also oversees the country's environmental protection, compliance with ratified international environmental conventions and inter-state environmental agreements; and controls emission and discharges of pollutants.
The Ministry has thirteen departments:

1. Administrative,
2. Budget and Finance,
3. Climate Policy and Green Technologies,
4. Digitalization and Informetrics,
5. Environment Policy and Sustainable Development,
6. Geology and Minerals,
7. Human Resources,
8. Internal Audit,
9. International Relations,
10. Legal,
11. Strategic,
12. Transboundary Rivers, and
13. Waste Management

The Ministry also has four committees:

1. Geology,
2. Forestry and Wildlife,
3. Water Resources, and
4. Ecological Regulation and Control.

Two departments within the Ministry oversee environmental matters:

1. Department of Climate Policy and green technology oversees low-carbon development, climate change mitigation, adaption and related risks, promotion of green technologies and projects as well as the development and implementation of state policy for environmental protection; and;

2. Department for Environmental Policy and Sustainable Development is in charge of the development and implementation of state policy for environmental protection including environmental monitoring and information exchange through unified state systems and transition to green economy policy.

Ecological Regulation and Control Committee is in charge for ensuring environmental safety and environmentally sustainable development of the society. The Committee is involved in improvement of the state regulation system in the field of environmental protection and ecological control. It holds state ecological expertise and issues ecological permits. The Committee oversees technical regulations, norms, rules and other requirements for atmospheric air protection, including release and operation of transport and other mobile vehicles. The Committee includes Ecology Departments – territorial bodies in charge for ecological regulation and control in all oblasts and cities of national significance.

Zhasyl damu JSC is a subordinate organization of the Ministry of Ecology, Geology and Natural Resources specialized on:

- Professional support to the Government of Kazakhstan in implementing the commitments under international environment and climate conventions,
- Greenhouse gas emissions management including maintenance of national GHG emission quoting and trading system,
- Orphaned hazardous waste management.

Zhasyl damu JSC in partnership with Ernst & Young is updating Nationally Determined Contributions and developing a roadmap to implement updated NDC for 2021-2025 under the World Bank project. BHT can be considered as one of the measures to reduce GHG emissions in the transport sector to be included to the Road Map.

2. Ministry for Trade and Integration

The Committee on Technical Regulation and Metrology of the Ministry for Trade and Integration aims to raise the quality and application of standards. Its objectives include increasing the competitiveness of Kazakh enterprises through the greater application of standards. It also works to harmonize Kazakh standards with international standards.

3. Ministry of Industry and Infrastructure Development

The Committee on Industrial Development and Safety of the Ministry leads the work in the areas of energy saving and improving energy efficiency. It was overseeing implementation of the 2013 Program *Energy Saving-2020* (2013 Resolution of the Government No. 904, overturned in 2016) and monitored the energy savings and efficiency plans being submitted by more than 1,000 companies.

4. Green Public Procurement

Government spending on Kazakhstan is an important source of aggregate demand in Kazakhstan. The Public Procurement Act 2015 requires public procurement organizers to provide several criteria for determining the supplier. One of the criteria is whether competitors have implemented certified environmental management systems and / or are in compliance with the ecological product standards specified in national technical regulations.

Legislative structures related to public procurement in Kazakhstan do not have sustainability criteria for goods and services to be purchased in specific sectors, such as buildings, roads and infrastructure, vehicles, agricultural waste and irrigation systems. There are no technical specifications or clauses dedicated to environmental or green goods and service individually, nor was there any connection with the Concept of Transition to the Green Economy.

5. Public–Private Partnerships in Support of Green Economy

Kazakhstan does not have a specific fund dedicated to public investment in environmental projects. That being said, there are several public financial institutions that have invested in projects designed to contribute to the country's transition to a green economy. The 2015 Law on Public Private Partnerships (PPP) does not itemize support measures with the scaling up of projects for green economy through PPP. However, the legislation indicates that it is among the main principles of PPP to increase the level of accessibility and quality of goods and services, taking into account the interests and needs of the population. PPP project proposals must contain a detailed section on environmental and social impact assessment, which aims to avoid the negative impacts of the projects on the environment and communities.

6. The Ministry of National Economy

The Ministry of National Economy leads the coordination of the implementation of environmental protection in the areas of strategic and regional planning, tax and budgetary policy statistics and functional analysis of public services.

Since 1 January 2018, the Astana International Financial Centre has been a special jurisdiction based on the principles of English common law, with a preferential tax regime and an independent financial court. To become a platform for investing in ecologically sustainable projects, green funding and lending for the issuing of green bonds, the Centre has established partnerships with stock exchanges, such as the London Stock Exchange, NASDAQ and Shanghai Stock Exchange.

In May 2018, the Government also announced the establishment of the International Centre of Green Technologies and Investment Projects. Activities planned include technological transformation of the energy sector, sustainable urban development, greening businesses, and transfer and adaptation of green technologies and best practices.

There are several working groups to implement the Concept and assist the Council. The groups most related to BHT are:

- Energy saving and energy efficiency;
- Reducing air pollution;
- Enlightenment and formation of ecological culture of the population.

7. Nur-Sultan Akimat

Nur-Sultan Akimat (City Government) administers local government services for the city of Nur-Sultan. It recognizes the important role in maintaining and building the country's economic potential. Nur-Sultan has an instrument of public-private partnership (PPP) which is viewed as a priority way to attract investments, for the Akimat of Nur-Sultan. The main instrument for implementing projects is private investment in the PPP mechanism.

In most situations PPP project implementation involves elements of financing, creation, operation of social infrastructure and life support facilities at the expense of the private sector, with the use of state support, including the provision of land, compensation for investment costs and other types of financial support.

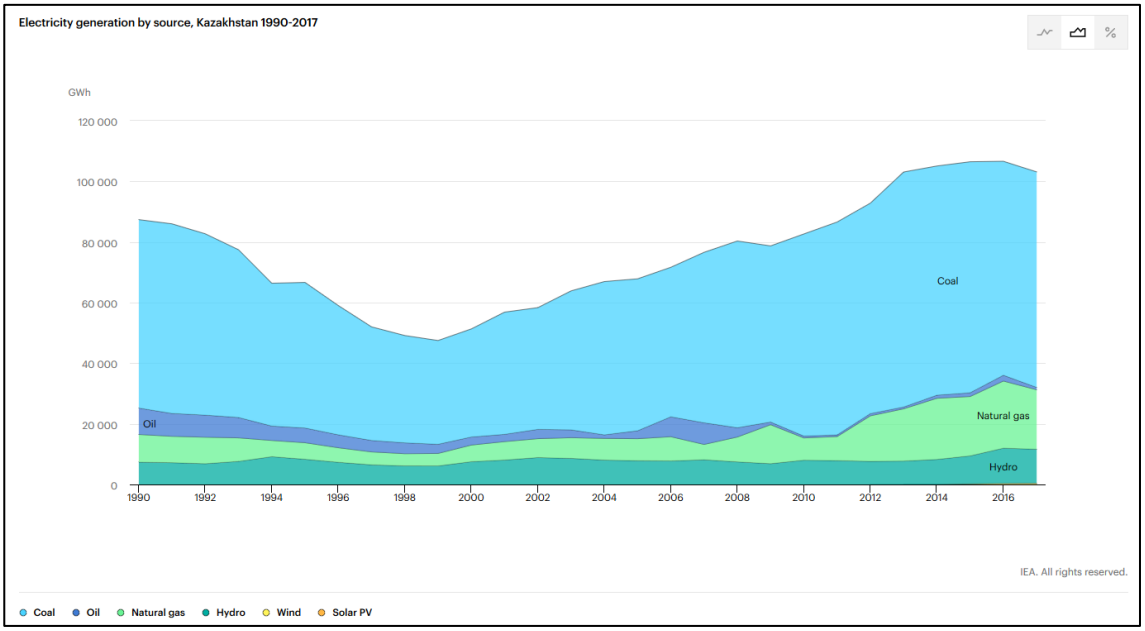
- In order to attract investors for the implementation of investment projects and mutually beneficial cooperation, *Astana INVEST City Investment Development Center LLP* operates under the Akimat of Nur-Sultan and within the framework of its activities provides advisory support for city PPP projects. The functions of the PPP Center include: development of all necessary documentation in accordance with PPP legislation (financial model, tender documentation, draft PPP contract);
- Provision of consulting services in the negotiation process of the PPP Commission with the bidder;
- Project support prior to the conclusion of the contract between the Akimat and the private partner; and
- Search for private partners (investors); holding round tables and seminars on PPP.

IV. ELECTRICITY GENERATION, TRANSMISSION AND DISTRIBUTION

1. Power Generation

Almost 80% of Kazakhstan's power generation comes from coal-fired plants located in the northern coal producing regions. Kazakhstan's hydroelectric facilities are located primarily along the Irtysh River, which flows from China across northeast Kazakhstan. Kazakhstan's electric power is predominantly generated from coal the huge coal deposits of northern and central Kazakhstan where the largest power plants is located. These regions satisfy their own power needs and have the potential for surplus electricity that can be offered to the internal and external power markets. Exhibit 6 illustrates the mix of power generation sources since the early 1990s.

Exhibit 6 Power Generation Mix for Kazakhstan (Source: IEA)



Electricity production in Kazakhstan is carried out by 155 power plants of various forms of ownership. As of January 1, 2020, the total installed capacity of power plants in Kazakhstan was 22,936.6 MW, and the available capacity was 19,329.7 MW. Kazakhstan's power plants are divided into national, industrial, and regional power plants. Power plants of industrial importance include Combined Heat and Power (CHP) with combined production of electrical and thermal energy, which are used to supply electricity and heat to large industrial enterprises and nearby settlements. Power plants of regional importance are CHPs integrated with territories that sell electricity through the networks of regional power grid companies and power transmission organizations, as well as heat supply to nearby cities.

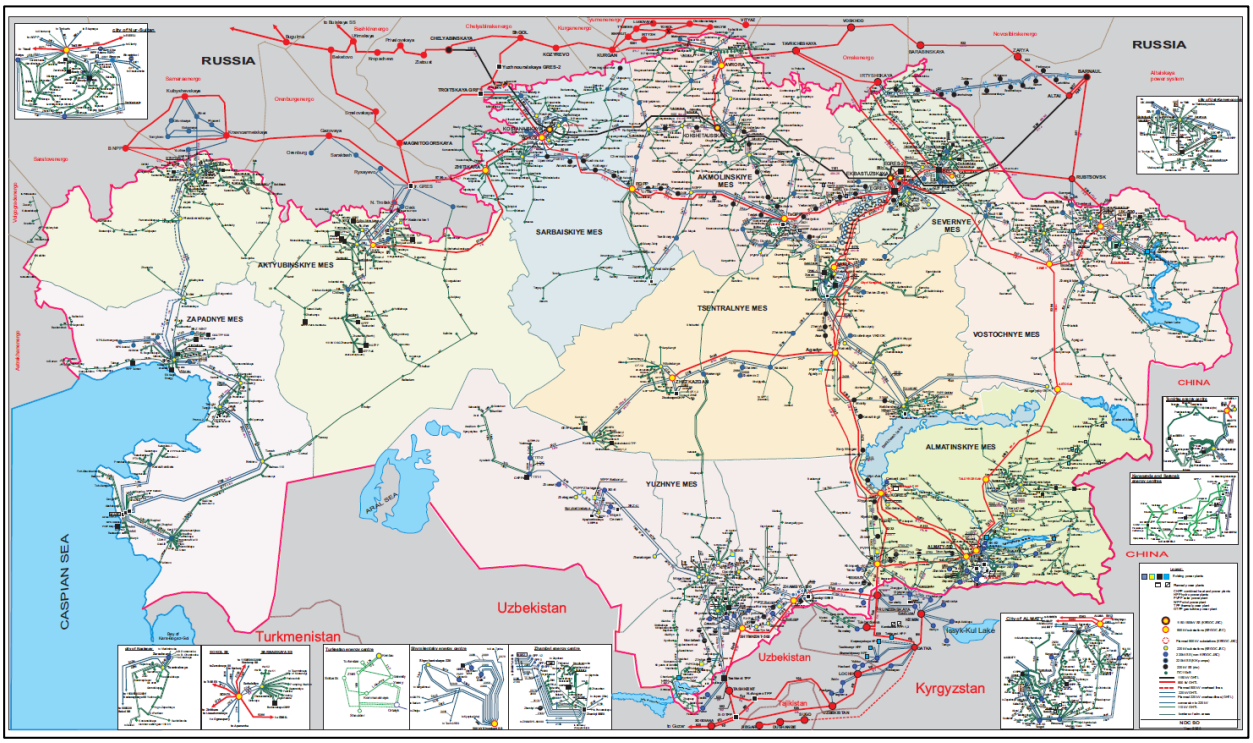
2. Power Transmission

Joint Stock Company "Kazakhstan Electricity Grid Operating Company" KEGOC was established in accordance with the Resolution of the Government of the Republic of Kazakhstan dated September 28, 1996 *No. 1188 On Some Measures To Restructure The Management Of The Energy System Of The Republic Of Kazakhstan*. KEGOC's Intersystem Electric Networks branches include 374 overhead power transmission lines with ranging from 0.4-1150 kV with a total length of 26,900.9 km

Electric networks of the Republic of Kazakhstan (see Exhibit 7) include a network of substations, switchgear and power transmission lines connecting them with a voltage of 0.4-1150 kV, intended for the transmission and/or distribution of electrical energy. The national electric grid

(NES), operated by KEGOC, and is Kazakhstan's backbone transmission network. It provides electrical connections between the regions of the country and the energy systems of neighboring states including the Russian Federation, the Kyrgyz Republic and the Republic of Uzbekistan.

Exhibit 7 Map of Kazakhstan Electricity Transmission Network and Interconnections



Kazakhstan's electricity transmission and distribution system is divided into three networks. The two in the north are connected to Russia, and the one in the south is connected to the Unified Energy System of Central Asia. One of the problems in Kazakhstan's power sector is a high amount of transmission and distribution losses. Technical losses are estimated at 15%.

Electric Power Supply Electric power supply system in Nur-Sultan includes 3,500 km of power lines, 925 substations, 210 distribution points and more than 3000 complete transformer substations and transformer substations.

3. Electricity Distribution in Nur-Sultan

The formation of Astana Regional Electric Grid Company (Astana-Rec) was established in 1980. It was then, on the basis of the Akmola urban district of electrical networks in accordance with the order of the Production Energy Association EO Tselinenergo No. 244 dated June 8, 1980 that the City Electric Networks enterprise was founded. In 2010, the enterprise received the status of a company servicing regional power grids, in connection with which it was renamed into JSC Astana - Regional Electric Grid Company.

Since 2014, Astana-Rec enterprise has operated the local distribution grid with two control rooms, special equipment warehouses, service vehicles, workshops, and laboratories. The company has modern dispatching and technological control facilities, a fleet of special vehicles, and mobile diesel power plants.

The intensive pace of construction of capital facilities, increased requirements for the quality of life of citizens contribute to the annual growth of electrical loads in the city. Based on the results of monitoring the growing loads to ensure reliable and efficient operation of the city's energy

complex, taking into account modern technical, economic and environmental requirements, the company's specialists together with the State Institution "Management of the Fuel and Energy Complex and Utilities of the City of Nur-Sultan" are developing and implementing modernization projects networks and substations, as well as the construction of new power facilities.

Astana-Rec was very much involved with electricity supply for many of Nur-Sultan's high profile projects including installing 110kV substations for EXPO-2017, the new airport, terminal and Olimp district. The company also has new substation projects underway for the light rail transit LRT system, and the Telman intensive development area.

For planning, accounting purposes, and in order to ensure safety, Astana-Rec has a procedure in place for new installation electricity panning, permits, inspections and commissioning as illustrated in Exhibit 8. The planning, permitting, installation and inspection of charging pile stations would need to comply with this procedure.

Exhibit 8 Astana-Rec System Connection Requirements

V. AUTOMOBILE AIR EMISSIONS, ENVIRONMENTAL REGULATIONS AND MONITORING

A. Environmental Impact for Typical Nur-Sultan Automobile

When starting a cold engine that has not been operating for several hours, the amount of emissions is significantly compared to a warm engine. This is due to rich air-fuel ratio and incomplete fuel combustion when the engine is cold. The amount of ground level hydrocarbon and carbon monoxide emissions decrease and level off as the engine reaches operating temperature. The largest component of exhaust gas is Carbon Dioxide (CO2). This is followed by Carbon Monoxide (CO), Volatile Hydrocarbons (VOC) and Nitrous Oxides (NOx). In addition, engine emissions include fine particles (PM 2.5) and soot. Exhibit 9 shows the annual estimated emissions for a single automobile idling during winter months in Nur-Sultan.

Exhibit 9 Estimated Annual Emissions in Nur-Sultan from Single Automobile Idling

Air Pollutant Emitted	Hazard and Health Impact	Estimated Annual Emissions in Nur-Sultan from Single Automobile
Carbon Dioxide (CO2) greenhouse gas emissions	Causes global warming to Earth	1,239 kg per year
Carbon Monoxide (CO)	Dangerous gas to humans	41.4 kg per year
Volatile Hydrocarbons (VOC)	Causes difficulty breathing for people with asthma, senior citizens and young children.	6,453 grams per year
Nitrous Oxide/Dioxide (NOx)	Causes haze and smog when exposed to sunlight. Can also cause acidic rainfall.	3,775 grams per year
Particulate Matter (PM 2.5 and Soot)	Causes difficulty breathing for people with asthma, senior citizens and young children.	309 grams per year

Exhibit 1 (from the Executive Summary) is a screenshot of a MS Excel calculator tool developed during the project to assess the environmental benefits of BHT. The user can select or enter key parameter values for outdoor temperature range, engine size (liters), fuel type, typical daily engine idling time, number of winter days and fuel costs. In turn the calculator computes the net emissions to the environment after deducting the incremental pollutants from power generation required to operate the BHT. The calculator then produces outputs including:

- Annual Reduced Carbon Monoxide [kg CO]
- Annual Reduced Volatile Hydrocarbons [grams VOC]
- Annual Reduced Nitrous Oxide/Dioxide [grams NOx]
- Annual Reduced Particulate Matter [grams PM]
- Annual Greenhouse Gas Reduction (kg CO2)
- Estimated Simple Payback for BHT installation (years)

Exhibit 10 is an output summary for a selection of scenarios using the previously indicated model. It shows that there can be greenhouse gas reduction of between 377 and 1317 kg per year for typical automobiles in Nur-Sultan. The model deducts the carbon emissions impact of power generation to operate the BHT. Moreover, the level of ground level air pollution in the form of carbon monoxide (CO), nitrous oxide (NOx), volatile organics (VOC), and particulate matter (PM 2.5 and PM 10) are dramatically reduced.

Exhibit 10 Estimated Impacts for BHT on Typical Nur-Sultan Automobile

Engine Capacity (litres)	**1.2 to 1.5 L , 4 Cylinder**	**1.5 to 2.0 L, 4 Cylinder**	**2.0 to 3.0 L, 4 or 6 Cylinder**	**Above 3.0 L**	**2.0 to 3.0 L, 4 or 6 Cylinder**
Fuel Type	Gasoline	Gasoline	Gasoline	Gasoline	Diesel
Daily Engine Idle Time (minutes)	45	45	45	45	45
Annual Reduced Carbon Monoxide [kg CO]	5.7	10.6	23.2	43.0	18.3
Annual Reduced Volatile Hydrocarbons [grams VOC]	2,415	3,285	4,835	6,564	5,696
Annual Reduced Nitrous Oxide/Dioxide [grams NOx]	1,383	1,903	2,828	3,860	5,056
Annual Reduced Particulate Matter [grams PM 2.5 and PM 10]	111	154	231	317	844
Annual Greenhouse Gas Reduction (kg CO2)	377	576	928	1317	932
Estimated Simple Payback for BHT installation (years)	2.5	1.8	1.2	0.9	1.3

B. Kazhydromet Meteorological Service

Kazhydromet, the national meteorological service operates 90 air quality monitoring stations across the country. Kazhydromet also acquired specialized environmental data analysis software supporting air quality monitoring data collection, instrument calibration, data verification and quality control, storage and reporting. The assessment of the ambient air pollution is conducted in accordance with Guidance 52.04.667- 2005, “Documents on the state of ambient air pollution in cities for informing government agencies and general public.”

Since 2012, Kazhydromet has annually expanded the range of measured parameters in ambient air with the help of acquired laboratory equipment and automatic monitoring stations. Between 2008 and 2017, the number of measured parameters increased from 16 to 35 in 2017. The degree of ambient air pollution is assessed by comparing impurity concentration with the maximum allowable concentration (MAC).

Three air quality indexes are used to assess the level of air pollution for a one-month period:

- Standard index (SI): the largest single concentration of any pollutant measured in the city, divided by the MAC;
- Highest frequency (HF): percentage exceeding the MAC: the highest frequency exceeding the MAC by any air pollutant in the city;
- Air Pollution Index (API5): an indicator of ambient air pollution. It is calculated using average values of concentrations of five substances with the highest MAC values divided by the MAC and compared with the harmful concentration levels of SO2.

Since 2017, the following air pollutants are being monitored:

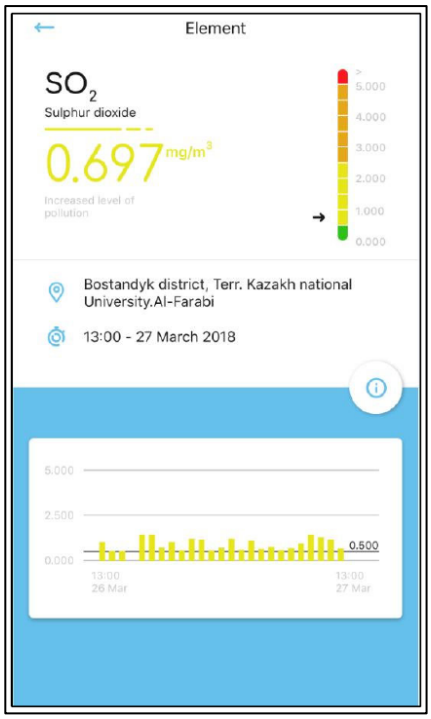
- ammonia,
- arsenic inorganic compounds,
- benzapyrene,
- benzene,
- beryllium,
- cadmium,
- carbon dioxide,
- carbon monoxide,
- chlorine,
- chrome,
- cobalt,

- copper,
- formaldehyde,
- hydrocarbons,
- hydrogen chloride,
- hydrogen fluoride,
- hydrogen sulphide,
- lead,
- manganese,
- methane,
- nitric oxide,
- nitrogen dioxide,
- non-methane hydrocarbons,
- ozone,
- petrol and ethylbenzene,
- phenol,
- soluble sulphates,
- sulphur dioxide,
- sulphuric acid,
- sum of hydrocarbons,
- suspended PM10,
- suspended PM2.5,
- suspended substances, and
- zinc.

1. National Real Time Air Quality Reporting

Kazhydromet developed an app (see Exhibit 11) on urban air quality (AirKz) to make official real-time data on air quality available to the public. Launched in 2018, AirKz allows users to monitor the quality of atmospheric air throughout Kazakhstan. In early 2019, AirKz provided information based on data collected in 46 settlements and at 84 automatic and 56 manual air quality monitoring stations.

Exhibit 11 Screenshot of AirKz Mobile App



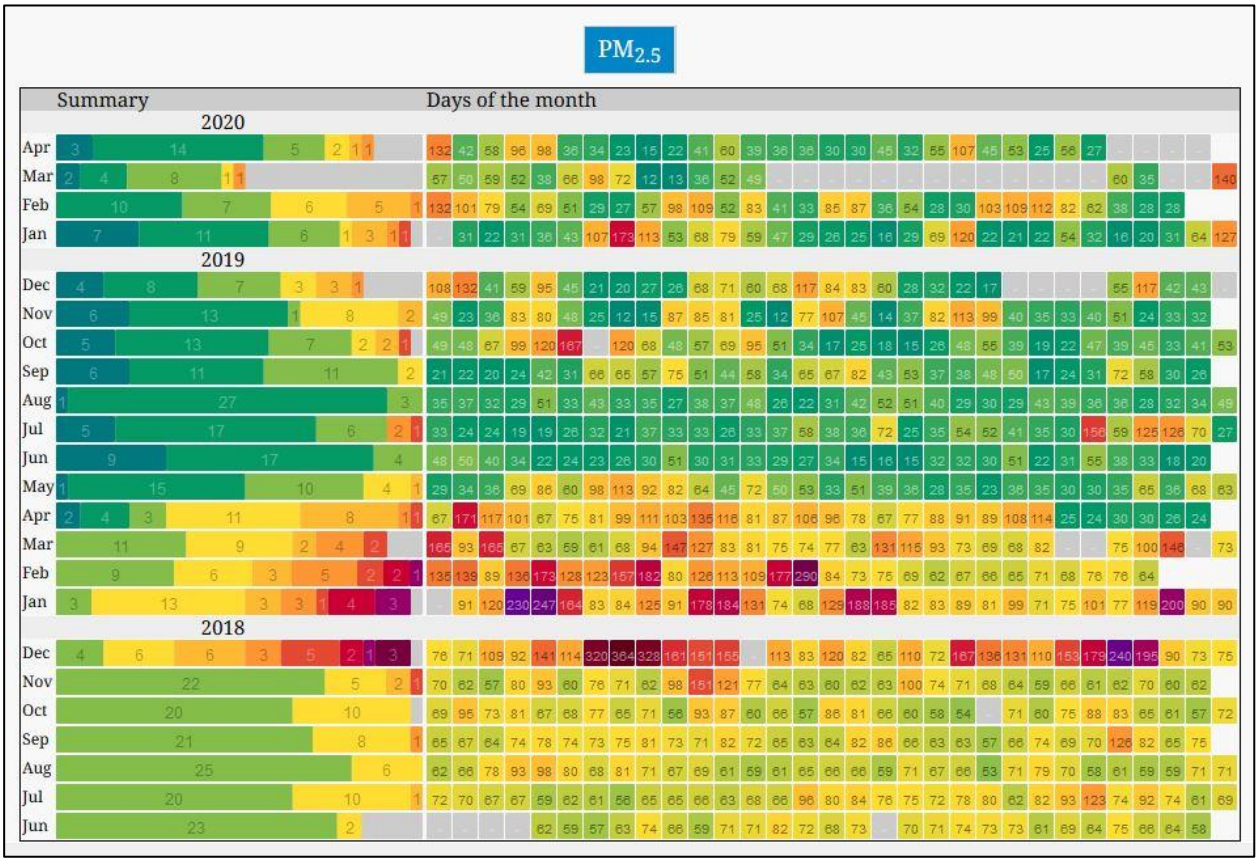
Available in English, Kazakh and Russian, AirKz allows users to manually select desired stations or, according to geolocation data, the app will automatically determine the nearest station. Depending on the selected station, the app displays the concentrations of the main air pollutants, notably nitrogen dioxide (NO2), nitric oxide or nitrogen monoxide (NO), PM10, PM2.5, dust, SO2, H2S, and CO. For each parameter, users can view the concentration level in mg/m3 and in relation to the MAC on a colour scale.

In addition to displaying monitoring data, AirKz includes a description of each pollutant and its effects on human health. However, it does not provide users with recommendations on what to do in the case of specific air pollution levels, nor does it include health risk maps or other health-related information. Awareness-raising campaigns promoting the use of the AirKz app have been carried out. In Nur-Sultan, the Smart Astana app is being developed by the local executive authorities and it is expected to integrate AirKz as well.

C. Nur-Sultan Air Quality

Exhibit 12 is a heat map presenting the PM2.5 air quality for Nur-Sultan. The air quality index clearly shows a trend for poor air quality during the winter months. This is especially noticeable during the period between December 2018 and February 2019.

Exhibit 12 Nur-Sultan Air Quality



VI. TRANSITION TOWARDS GREEN ECONOMY

1. Extractive Industry and Sustainable Development

Since the country's independence, the extractive sector has been the mainstay of Kazakhstan's economy. Making the transition to a market economy was initially difficult and was complicated by low commodity prices and historic ties to Russia's economy. Royalties from the extractive sector helped drive the economic growth between 2000 and 2013, averaging almost 41 per cent of GDP.

The Strategy of Industrial-Innovative Development for the period 2003–2015 (2003 Decree of the President No. 1096, annulled in 2010) was a landmark document in establishing industrial policy in Kazakhstan. The Strategy set out the principal target of fostering sustainable development through the development of non-extractive industries.

It also identified export competitiveness as a way to test success. While the strategy recognized the role of extractive sectors in the economy of Kazakhstan, it left the development of those sectors for state intervention through specific sectoral programs. The strategy also set a number of numerical goals: more than 8 percent growth in manufacturing sectors, three times more labour productivity, and 50 percent less energy intensity.

2. Kazakhstan Green Economy Transition Concept

Kazakhstan Green Economy Transition Concept (Decree of the President of 30 May 2013 No. 577 as amended by the Decree of the President of 10 September 2019 No. 151) is a key document that defines the basic approaches and target indicators in the field of rational use of natural resources, improvement of energy efficiency and energy saving, reducing greenhouse gas emissions and developing renewable energy sources. The Concept will be implemented in three stages:

1. 2013 to 2020,
2. 2020 to 2030, and
3. 2030 to 2050

The bulk of investments will be from private investors.

The Concept sets the following main principles to transfer to green economy:

1. Increase in resource productivity;
2. Accountability for resources used;
3. Economy modernization via the most effective technologies;
4. Ensuring investment attractiveness of efficient resource use activities;
5. Implementation of cost-effective activities;
6. Development of an environmental culture among businesses and population.

Green economy target in air pollution is to reduce sulphur and nitrogen oxide to the European emission level by 2030. GDP energy intensity level of 2008 will be reduced by 25% by 2020, 30% - by 2030, 50% - by 2050.

3. Environmental Code

Kazakhstan's 2007 Environmental Code states that emissions payments are among the main mechanisms for economic regulation to protect the environment and use natural resources. The law states that emission payments must be determined and imposed in the procedure provided for in the 2017 law on taxes and other mandatory budget payments (the Tax Code). For industry, emissions above the permissible emission limit values (ELVs) are subject to pollution

taxes while pollutant emissions over ELVs are subject to administrative penalties and cash payment for environmental damage. ELVs are assigned in permits, issued by environmental authorities at the national or regional level depending on the size of the process.

4. Kazakhstan's Strategic Development Plan Until 2025

The Strategic Development Plan of the Republic of Kazakhstan until 2025, approved by the Decree of the President of the Republic of Kazakhstan dated 15 February 2018, approves key target indicators in the field of low-carbon development, related to the reduction of the energy intensity of GDP by 20% by 2021 from the level of 2008, by 25% by 2025 and by 50% by 2050, while the share of electricity from renewable sources should be 3% by 2021 and 6% by 2025.

In order to achieve these target indicators, the necessary legal framework had been created - the Concept for the Development of the Fuel and Energy Sector of the Republic of Kazakhstan until 2030, the Law of the Republic of Kazakhstan "On Energy Saving and Energy Efficiency", the Law of the Republic of Kazakhstan "On Supporting the Development of Renewable Energy Sources."

In accordance with the Law of the Republic of Kazakhstan "On Energy Saving and Energy Efficiency", the main directions of the state policy in this area are:

- Ensuring energy efficiency of buildings, constructions and structures;
- Use of energy-saving equipment and materials;
- Energy efficiency of electrical energy consuming devices.

5. Pollution Taxes

It is estimated that about 30 percent of revenue from environmental fees is spent on environmental protection measures. Some of the environmental payments are used as a form of support to address other problems, economic or social, and that insufficient resources are allocated to treat or reduce pollution and its effects on human health or the environment.

In 2018, the Ministry of Ecology, Geology and Natural Resources embarked on a process of revising the Environmental Code to better align environmental regulations and the payments system with the polluter pays principle. The Environmental Code reform process includes reforming environmental taxes and non-compliance payments, environmental quality standards, impact assessment and licensing procedures, government environmental controls and controls, and incentives to introduce green technologies. The reform provides an opportunity to restore credibility in the regulatory system and align laws governing environmental taxes, fines and damages with the objectives of environmental policy and international obligations of Kazakhstan.

6. Vehicle-Related Taxes

Kazakhstan has carried out a significant reform of excise duties on the use of gasoline and diesel. According to the Tax Code, the vehicle tax rates differ according to the volume of the engine (cm3). For example, the tax rate for a vehicle with an engine size between 3,000 cm3 and 4,000 cm3 is 15 times higher than for a vehicle with an engine size less than 1,100 cm3, while for a car with an engine size greater than 4,000 cm3 the rate is 117 times higher. From an environmental point of view, this can theoretically incentivize the purchase of smaller cars that, other things being equal, are less harmful to the environment. If a car with an engine of 3,000 cm^3 and more was locally produced or imported after 31 December 2013, then tax rate varies from 35 to 200 monthly calculation indexes depending on the engine size.

Since 1 January 2020 (see Exhibit 13), the special sales tax rate for gasoline producers during the summer (July-November) has more than doubled (from 10,500 KZT to 24,435 KZT) and the

diesel fuel rate remained the same - 9,300 KZT. A similar increase was applied to producers' retail sales and imports. While these increases are noticeable, there still exists a large gap between rates in Kazakhstan and those commonly used in OECD member countries. For example, even for the highest rates under current legislation (24,935 KZT per tonne), the tax equals US $ 0.04 per liter.

Exhibit 13 Excise Tax Rates On Gasoline And Diesel Fuels 2020 (KZT Per Tonne)

Fuel Type	Gasoline	Diesel
Wholesale sales of gasoline and diesel fuel by producers (July to November)	24,435	9300
Wholesale sales of gasoline and diesel fuel by producers (December to June)	24,435	540
Wholesale sales of gasoline and diesel fuel by individuals and legal entities	0	0
Retail sales by producers of gasoline and diesel fuel (July to November)	24,935	9360
Retail sales by producers of gasoline and diesel fuel (December to June)	24,935	600
Retail sales by individuals and legal entities of gasoline and diesel	500	60
Imports	24,435	540

This still leaves a large gap with respect to Directive 2003/96/EC that restructures the community framework for the taxation of energy products and electricity, which establishes a minimum special tax rate of US $ 0.44 per liter for unleaded gasoline for use in vehicle engines However, vehicle taxation, does not yet take environmental impacts into account.

7. Emission Trading System

Kazakhstan was one of the leading countries in setting commercial quotas for greenhouse gas emissions. The 2011 amendments to the Environmental Act created a framework for the greenhouse gas emissions trading system (KazETS). Under this system, emissions from the most emitted sectors and activities were identified, and tradable emission allowances (shares) were allocated to individual companies.

This market-based mechanism provides for any excess amount of greenhouse gas emissions to be compensated for with the relevant amount of quota units (either provided due to the implementation of special measures to reduce greenhouse gas emissions or are created by implementing projects to absorb greenhouse gases) that can be purchased from the commodity exchange.

Government Decree No. 370 of 2017 established the rules for allocating greenhouse gas emissions shares and forming reserves. The specified quantity and the amount of the shares of the national plan for allocating greenhouse gas emissions use two methods of allocation. It also specifies how to determine the commitments to reduce emissions for each year. The units received through implementing measures to reduce greenhouse gas emissions are not limited in time. The additional quota allocation mechanism is also regulated (2016 Minister of Energy Order No. 292).

Although the sale of emission quotas is fully compatible with the polluter pays principle and generally does not distort the price signals of tradable shares, Kazakhstan has not yet entered it due to its lack of capacity to develop necessary procedures, methods and measurement methodologies.

The experience of member countries of the Organization for Economic Cooperation and Development shows that failure to move towards auction usually weakens the environmental

effectiveness of the system. KazETS has been an important tool in fulfilling international obligations to reduce greenhouse gas emissions in the country.

There were a number of elements in the KazETS legislation that did not work properly. As a result, the system was suspended until January 2018 and the intervening period was used to improve the provisions of the system, including the method of allocating stakes, creating and distributing stakes from the reserve, specific tariffs and overseeing the carbon trading platform.

VII. VEHICLES, FUEL AND GRID IMPACT

A. Kazakhstan National Vehicle Fleet

As of 2019, motor vehicle fleet in Kazakhstan constituted around 4.6 million units, 82% of which are passenger cars. Passenger cars dominate the motor transport fleet of Kazakhstan, with total number of cars passing 3,909,831 units as of 1 August 2020. Due to the combination of income growth and availability of bank loans, the number of private cars has been rapidly growing since 2000. 2.5 million passenger cars (almost 65%) are 10 years and older. The largest number of passenger automobiles under three years is in Almaty city and Nur-Sultan. About 847 thousand of all passenger cars range from 3-10 years in age.

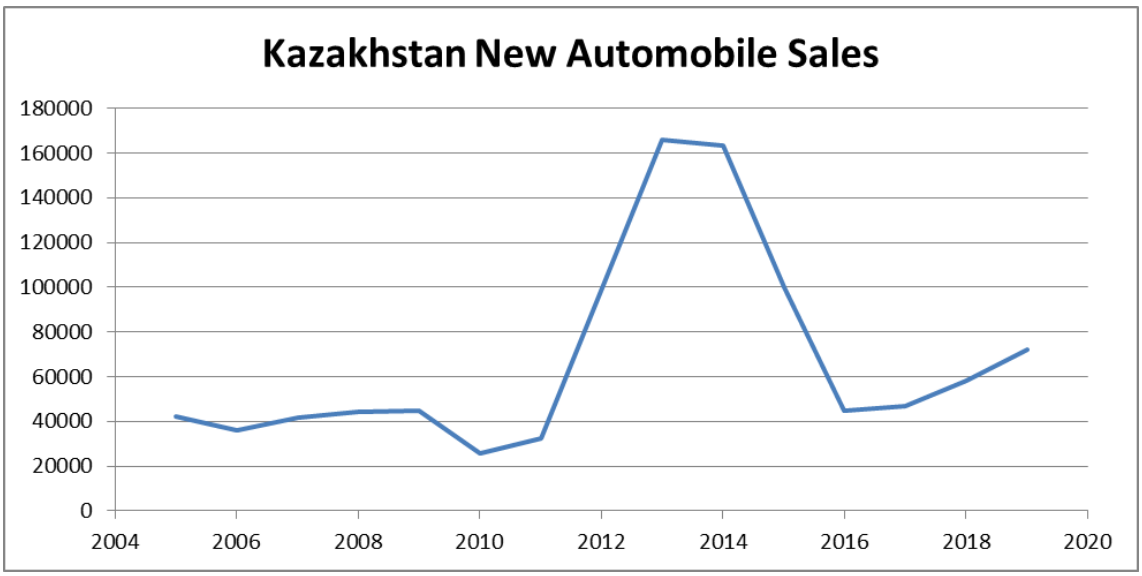
The estimated number of heavy trucks in Kazakhstan in 2019 was 446,475 units, and the total number of registered buses in Kazakhstan reached 59,516 units.

According to the Ministry of Internal Affairs of the Republic of Kazakhstan, almost 82% of all registered passenger cars have engine size in the range from less than 1.1 to 2.5 liters. Planned increase of vehicle tax for cars with engine size bigger than 3.0 liters could reduce the share of such vehicles in the fleet from 2014.

1. New Automobile Sales

Exhibit 14 shows the trend for new automobile sales in Kazakhstan from 2005 to 2019. Following 2008-2009 world economic crisis, there were national policies to stabilize Kazakhstan's economy including attractive loans to purchase locally manufactured cars. The two predominant years were 2013 and 2014 and this was attributed to stabilization in the economy and overall GDP growth in 2013. Subsequent currency devaluations in 2015 and decline in consumer purchasing power resulted in decrease of new car sales. In 2019, new automobile sales were 72,081 units.

Exhibit 14 Kazakhstan New Automobile Sales by Year (2005-2019)



2. Most Popular Brands and Model Types

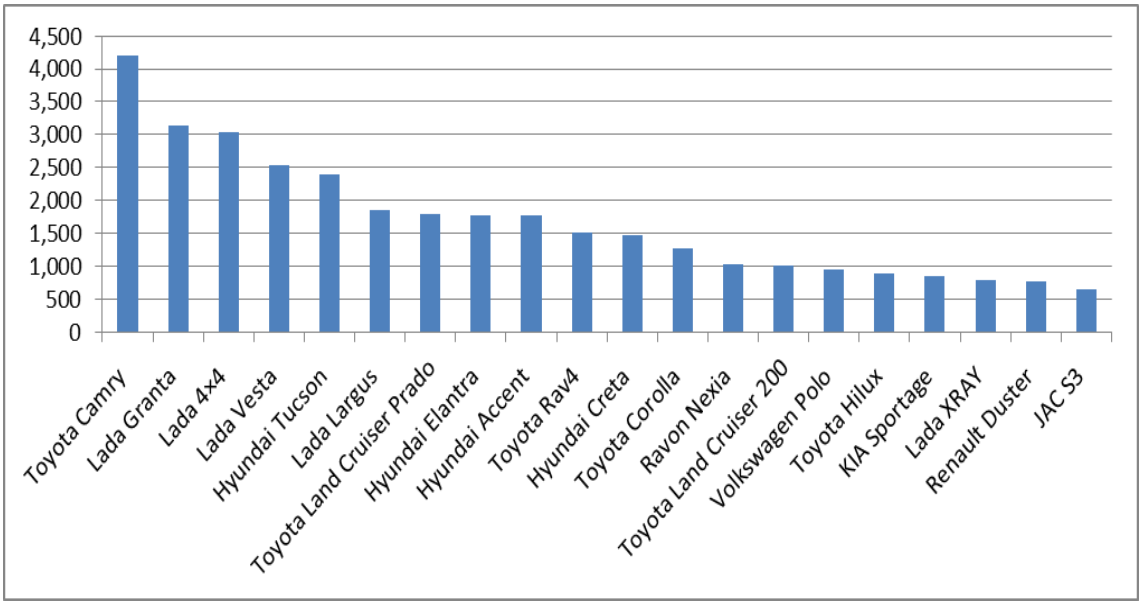
By ranking the most popular brand of automobiles sold in Kazakhstan during 2018 are shown in Exhibit 15. Note that the total is 44,427 and does not include the domestically assembled vehicles to make the total 72,081.

Exhibit 15 Most Common Imported Brands in Kazakhstan

Brand	Units Sold (Total= 44,427)
Lada	12,061
Toyota	11,215
Hyundai	7,626
KIA	2,593
GAZ	2,463
Nissan	2,188
Renault	1,824
Ravon	1,727
Volkswagen	1,382
UAZ	1,348

Exhibit 16 shows the most popular models of new vehicles sold in Kazakhstan in 2018. The most popular vehicle was the Toyota Camry with 4,208 units sold.

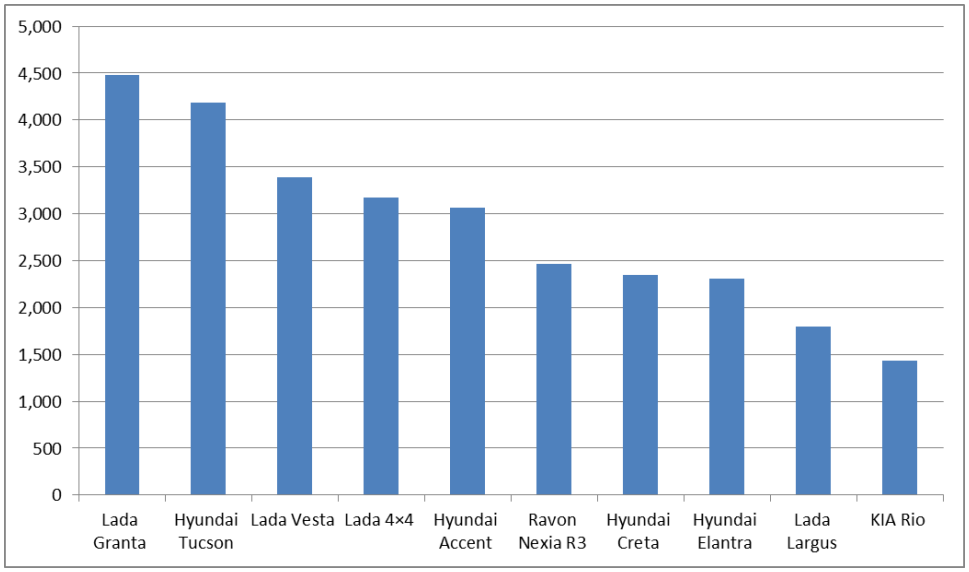
Exhibit 16 Kazakhstan Most Popular New Automobile Brands and Makes for 2018



3. Domestic Automobile Assembly

The number of domestically assembled vehicles continues to rise in Kazakhstan. Exhibit 17 shows the number of domestically assembled vehicles ranked by brand and model type for 2019. The top produced model was the Lada Granta with 3,378 units.

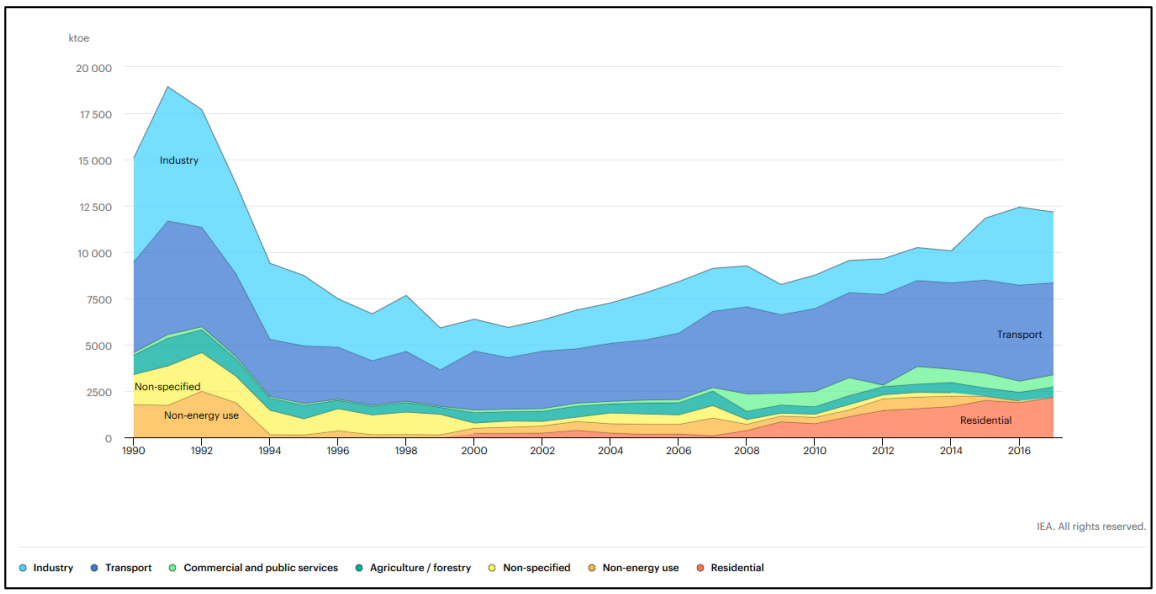
Exhibit 17 Kazakhstan Domestically Assembled Vehicles in 2019



B. Fuels

As shown in Exhibit 18, Kazakhstan's Transport sector consumes about 40 percent of oil products.

Exhibit 18 Kazakhstan Oil Products Consumption by Sector 1990-2017 (Source: IEA)



Over 89% of all passenger cars in the country use gasoline, while the share of vehicles run on diesel, gas (CNG and LPG) and hybrids (including fully electric vehicles) are together almost 11% of the overall total. Retail prices of gasoline (Octane 92, Octane 95 and Octane 98 grades) and diesel are subject to state regulation. The Committee for the Regulation of Natural Monopolies (CRNM) sets the maximum retail prices.

Due to expansion of the vehicle fleet and increasing consumption of fuels, emissions of exhaust gases by road transport is one of major source of air pollution in Kazakhstan, especially in the large cities. Concentration of major pollutants in the air exceeds maximum allowable levels in most province-capital cities of the country, whereas in half of these cities deterioration of air

quality became an acute problem. Though occupying comparatively small share in the country`s total GHG emissions, road transport has been also exhibiting the most rapidly increasing carbon footprint since 1992.

The low quality of fuels was a venerable problem, and there is evidence that considerable part of fuels at the refueling stations all across the country did not match nominal standards and requirements. In 2012, Kazakhstan ranked 92 out of 100 countries in terms of fuel quality. The government had to take required measures to change the situation modernize the refineries that were built up during the Soviet time.

The State Industrial and Innovation Development Program for 2015-2019 (Decree of the President No. 874 of 1 August 2014) and Republican Industrialization Map for 2015-2019 (Decree of the Government No 1418 of 31 December 2014) provided for investment projects to develop and modernize Atyrau, Pavlodar and Shymkent refineries which were finalized in 2018. Modernization of refineries ensured production of K4, K5 class fuels (equivalent to Euro-4 and Euro-5) with low content of sulphur and hazardous carcinogenic substances which has a positive impact on environment.

New refinery facilities were equipped with advanced test and measuring devices, distributed control system and accident-prevention system to ensure smooth and reliable process control. Volume of oil refining amounted to 17.12 million tons what is 4.4% higher than 2018 with 16.39 million tons. In 2019 Kazakhstan’s refineries produced 12.7 million tons of oil products what is 9.5% higher than 2018 when 11.6 million tons were produced. Oil product endowment of the domestic market reached 100% in 2019.

1. Emission Standards for Vehicles

In 2007, the government adopted Technical Regulations *Technical Requirements to Transport Vehicle Emissions*, which established new environmental standards for fuels and vehicles, and provided a roadmap for a gradual introduction of these standards in Kazakhstan from 2010 to 2016. The Technical Regulations were cancelled in January 2017.

Introduced on 1 July 2018, National Standard 1433-2017 “*Road Transport. Emissions of Pollutants with Exhaust Gases from Vehicles into the Atmospheric Air. Calculation Norms and Methods*” sets normative requirements and methods to control emissions of pollutants with exhaust gases from operating vehicles into the atmospheric air. Norms of carbon oxide in exhaust gases from gasoline or gas engine during idling shall not exceed the values indicated by a vehicle manufacturer or the values indicated in Exhibit 19. This Standard shall be used during mandatory technical inspections, random checks of exhaust gas emissions from vehicles by transport control bodies, etc.

Exhibit 19 Legislated Maximum Permitted Emission Levels

Category and Configuration of Vehicles	**Crankshaft Speed**	**Carbon Oxide, volume, %**
Cars, buses and trucks not equipped with exhaust gas after treatment systems	Minimal	3.5
	Increased	2.0
Cars, buses and trucks, ecological class 2 and lower, equipped with exhaust gas after treatment systems	Minimal	0.5
	Increased	0.3
Cars, buses and trucks, ecological class 3 and higher, equipped with exhaust gas after treatment systems	Minimal	0.3
	Increased	0.2
Bikes not equipped with exhaust gas after treatment systems	Minimal	4.5

As the country is a member of the Customs Union, fuel standards became subjected to Technical Regulation of the Customs Union *On Requirements For Automobile And Aviation*

Gasoline, Diesel And Marine Fuel, Jet Fuel And Heating Oil (TR TC 013/2011), that came into force on 31 December 2012. This document sets norms for gasoline and diesel fuels of four ecological classes, as well as gradual withdrawal and introduction of a fuel of some ecological class.

According to the legislation, all vehicles registered in Kazakhstan are required to undergo regular mandatory technical inspection, including compliance validation of engine exhaust gases emissions to maximum allowable concentrations. The vehicle technical inspection is performed by private companies, accredited by the Transport Committee of the Ministry of Industry and Infrastructure Development. The inspection centers are equipped with both stationary and mobile inspection lines, and reportedly use advanced electronic equipment for performance tests. Obligatory technical inspection is conducted annually – for vehicles of more than seven years old; every two years – for vehicles between 3 to 7 years old; and once in three years – for vehicles less than 3 years old. Additionally, there can be unscheduled examinations of vehicle exhaust gases emissions pursued at various locations on roads by Environmental Prosecutor office representatives along with road police officers.

C. Impact of BHT to Nur-Sultan Distribution Grid

Taking into consideration that the vast majority of Kazakhstan's electricity is produced from coal and the extent of technical losses, the carbon intensity for the power system is approximately 0.87 kg CO2 per kWh generated. This factor was used as a penalty to offset the environmental benefit of not having to burn fossil fuel while the automobile engine is idling.

Each engine block heater and interior car cabin heater can consume between 0.700 kW and 1.900 kW for a period of 4 hours. A Monte Carlo simulation (see Exhibit 20) is based on simulating 1000 typical automobiles acting under randomized conditions within the range expected for Nur-Sultan. Randomized variables include outdoor temperature, engine size, daily number of minutes of idle time, block heater power consumption, and time the block heater is energized.

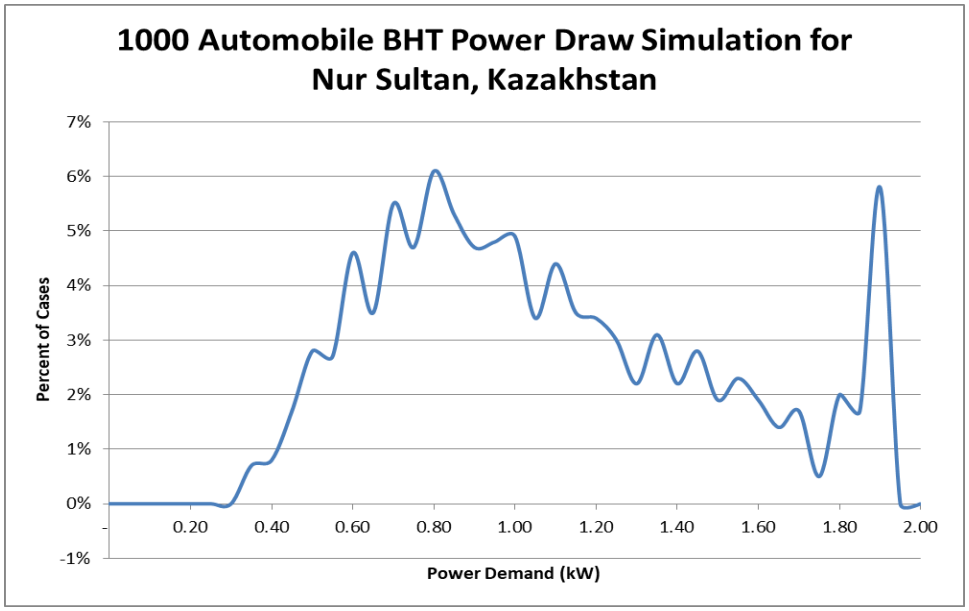
The simulation boundaries indicate the range of power consumption on a typical winter peak day. Variable components include:

- Power demand between 0.7 to 1.9 kW
- Fraction of installed automobiles with BHT actually using the BHT (estimated between 70 and 95 percent)
- Outdoor Temperature between -10°C and -35°C (the colder the temperature, the longer the time of continuous operation)
- Diversity Factor that automobiles would draw power from the grid for the BHT simultaneously estimated between 70 and 85 percent

The model output indicates that the median power demand per vehicle would be 1.02 kW, the average power demand 1.07 kW, and the standard deviation 0.413 kW. Using an upper bound of 2 standard deviations (95.4% of the time), maximum power demand would be 1.88 kW, which is about the maximum capability of the BHT equipment. Therefore, each 1000 automobiles would, on average, add 1070 kW to the overall power demand for Nur-Sultan.

Depending on the number of automobiles installed or retrofitted with the BHT, localized grid impact studies would need to be done to test the adequacy of the electrical grid.

Exhibit 20 Monte Carlo Simulation of Power Demand for Typical Automobile in Nur-Sultan



VIII. PUBLIC AWARENESS AND PARTICIPATION

To improve public awareness and participation, one of the CPS was situated in a highly visited area of Nur-Sultan. Each CHP included an ADB nameplate with a QR code as shown in Exhibit 21.

Exhibit 21 QR Code on Charging Pile Station for Public Awareness

When a passer-by scanned the QR code, they would be linked to an “Explainer” document (Exhibit 22) hosted on the Development Asia website with basic information about the BHT.

Exhibit 22 Block Heater Technology Explainer

development ASIA
An initiative of Asian Development Bank

sharing development know-how

EXPLAINER

How Block Heater Technology Can Reduce Carbon and Air Pollution

Using a block heater to warm a parked car engine during cold winter months can reduce carbon emissions and other pollutants. Infographic: ADB.

Idling of motor vehicles during wintertime generates greenhouse gas emissions and other air pollutants, but engine block heaters can lessen the negative impact on the environment.

Introduction

Starting a vehicle on a cold winter day can be difficult. It can be hard on the engine, wallet and the environment. It wastes fuel, emits air pollution and greenhouse gases, and puts unnecessary wear and tear on the engine.

When the vehicle engine starts, it circulates oil throughout the engine block to lubricate the moving parts. On winter days when the engine is cold, the oil is very thick, and the engine must work harder to overcome internal friction.

When the temperature outside is below 0°C, the engine can consume about 25 percent more fuel after a "cold start" than when the engine reaches its normal operating temperature. For an average vehicle with

IX. BUSINESS MODEL

1. Sustainable Block Heater Infrastructure

Introducing a new technology like BHT is sometimes viewed as a “chicken and egg” problem to overcome. The recommended approach is to introduce BHT with fleet operators in Nur-Sultan such as Astana Taxi, the many virtual taxi providers, municipal vehicles such as police cars, snow ploughs, and emergency service vehicles.

In developing the business model for BHT and CPS, the framework shown in Exhibit 23 was used.

Exhibit 23 Sustainable BHT and CPS Business Model Framework

Market Analysis	
Demand	How does anticipated use determine the scope of work for charging stations and CPS-ready sites?
Host Location	Does the retail, commercial or residential location affect the rate of use?
Target Markets	What are the host’s motivations and goals for CPS installation?
Economic Factors	
Construction and Engineering	Is trenching or other heavy work required? Who will certify the civil engineering and electrical safety of the installation?
CPS Cost	Will any grant or program funding be available? What is the marginal cost of additional CPS?
Fiscal Impacts	What costs and benefits are associated with public or government-installed CPS?
Maintenance	What will be the annual upkeep cost?
Revenue	What business model is most appropriate for recuperating the host’s or network’s capital outlay?
Service Upgrade	What is the cost of a service upgrade? How does this impact location?
Legal Issues	
Land Rights and Use	Are there any local barriers to where CPS can be installed?
Liability	What entity takes responsibility for any necessary insurance or other liability measures for BHT and CPS?
Regulations	What codes and ordinances apply to the site, construction and electrical installation?
Contractual Terms	What agreements and contracts are necessary or advisable to install and operate CPS?
Operations	
Equipment	Will installation require equipment or technology upgrades beyond the charging station itself?
Management	What entity (host/site owner/network/municipality) will operate and maintain the CPS?
Dual Use Scenarios	What alternative installation scenarios could reduce costs or increase revenue?
Electric Power Utility	What upgrades to service, conduit installation, and metering are needed for CPS?

2. Revenue Collection and Cost Recovery

Revenue models for CPS stations are still subject to discussion and review in Kazakhstan. Some of the common revenue models are explained below for commercial/public charging operations:

- Free parking. Free Charging. In this scenario, the parking lot operator would install a charging station for the benefit of its customers. An example of this would be a store, or shopping mall or hotel installing a CPS as a means to attract customers

- Paid Parking with Free CPS. In this scenario, the parking lot operator would charge a flat rate for the parking stall which would include power. The incremental fee would be charged to all users of the parking lot regardless of whether or not they use the CPS.
- Flat Rate Charging Fee. Unlimited charging for a flat fee. This would be more applicable for residential buildings or office buildings where they are assigned parking spots.
- Metered Charging – Users charged per kilowatt hour (kWh) of electricity supplied

a. Card Readers

Several types of card readers that may be incorporated with the CPS are available. Credit/debit card readers would be simple to use and are already widely accepted in Kazakhstan. In all of the non-cash/coin payment options discussed, a communication system from the reader to a terminal for off-site approval and data recording could be required and should be factored into the installation budget.

b. RFID and Smartphone Billing

A smartcard is a card that is imbedded with a microprocessor or memory RFID chip. Several smart phones also have the capability to connect with RFID or other wireless protocols like Bluetooth to enable payment processing. It can more securely store more detailed information than a credit/debit card. The detailed information could be captured in each transaction and used for data recording. The smartcard could be sold as a monthly subscription and imbedded with information on the user. Other payment options include the user prepaying for a preset number of charge opportunities or having their credit card billed for each time of use.

c. Parking Area Meters

People are very familiar with parking meters used in public parking. A simple coin operated meter is an option for EV parking areas and can be installed at the head of each CPS parking stall. Another method in common use is for public pay parking lots where a central kiosk is used for credit card purchases. The parking stall number is identified at the kiosk and a parking receipt is issued, which can be displayed in the vehicle. Using a single kiosk reduces the point of service cost for the whole parking lot. This system will require an attendant to periodically monitor the area for violations.

d. RFID Subscription Service

Like the smartcard, a Radio Frequency Identification (RFID) fob can be programmed with user information. The RFID reader collects the information from the fob to activate the CPS. Potential payment options are also similar to those of smart cards including monthly subscriptions, prepaid and linked credit card building.

3. Engineering, Permitting and Construction

The typical permit application for civil and electrical modifications would include the name of the owner or agent, the actual address to perform the task, the amount of voltage and current in the system, the name of the qualified contractor, the address and license number, and whether. Service load calculation may be required.

Electrical contractors can review the current service load and consider the class of CPS to be installed. The new load calculation determines whether an existing service panel is suitable or if a new service is needed.

Installation drawing requirements may vary by jurisdiction to include a simple electrical line drawings and civil construction layout for the installation of a residential area, and a complete

plan for utility metering. In general, electrical engineering firms and contractors can complete the requirements for residential garage circuits. For CPS installations, it is recommended that engineering companies prepare detailed site plans for each installation. It can include multiple deals including general contracts, electricity, landscaping, pavement, concrete, and masonry and telecommunication systems.

- Coordinating these efforts requires careful planning, and engineering companies can provide the set of detailed drawings required. In addition, there may be several permitting offices in connection with the approval of this plan.

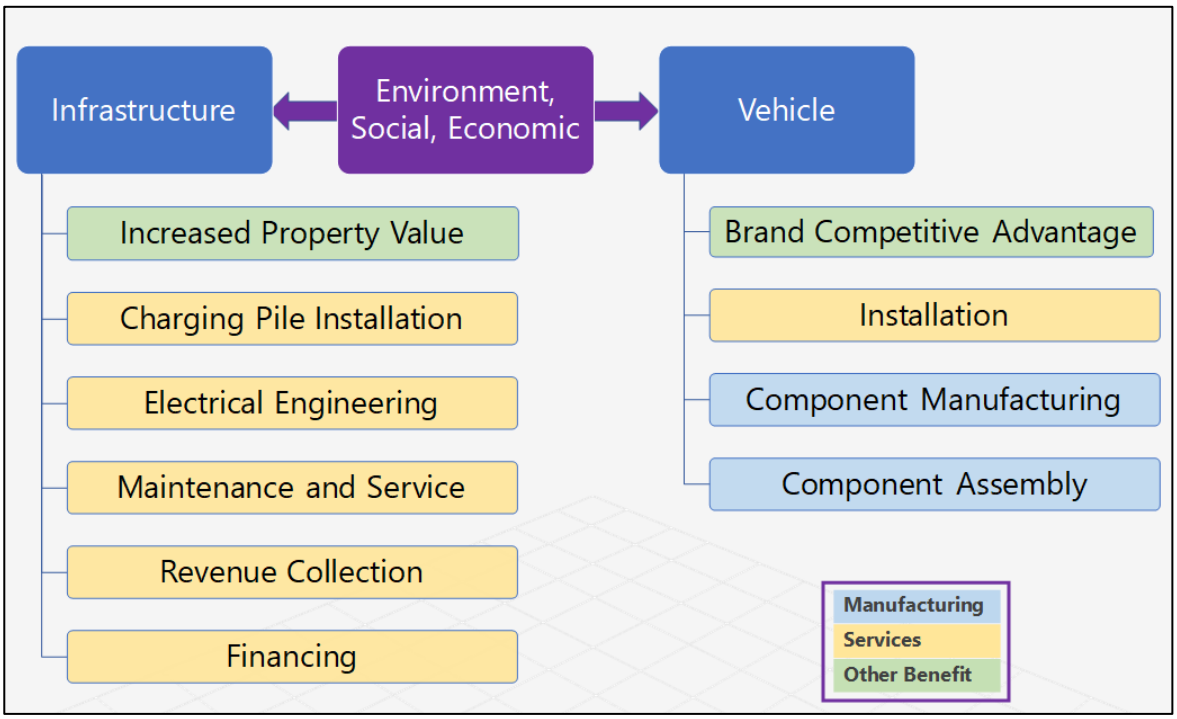
- Permits must be approved and posted on site prior to actual field work. Permits identify regular inspections and work approvals as needed.

4. Localization and Economic Value Creation

As illustrated in Exhibit 24, engine block heater can benefit both the infrastructure and vehicle value chains in Kazakhstan.

- For infrastructure, there are increased opportunities for installers, engineers, maintenance services, finance and revenue collection entities.
- On the automobile side, there are potential opportunities for installation and servicing by automobile suppliers and local service companies.
- Manufacturing and technology transfer or technology licensing opportunities exist for local Kazakhstan companies to produce block heater CPS stations, wire harnesses, internet of things RFID devices and other value added components.

Exhibit 24 Value Added Localization for Infrastructure and Vehicles



5. Charging Pile Station Ownership

The ownership of the individual charging station will vary from place to place. A business entity may wish to host a public charging station, but may not have the legal rights to park the car or

the rights to make improvements. Charging stations created with public grants or other financing may have a divided property.

One entity can own the CPS station and another entity can own the infrastructure. The sale of businesses can include CPS, or can include the sale of both properties. You can lease CPS or rent equipment. Before planning any installation, it is important to identify the entities that have legal rights in relation to the equipment and the property on which they are installed to determine the necessary approvals required to obtain permits and future plans to withdraw the equipment at the end of its cycle of lifetime.

For individual electric vehicle owners living in a single-family home, CPS residential property is more likely to fall to the owner. Rather, the building owner is likely to be the owner of the installed CPS for commercial and multi-residential building complexes. Utilities may wish to own and manage public transportation infrastructure to manage energy requirements. In a successful advance in the electric car market, the new public rate property can become private property.

Several companies can join together to promote the use of BHT and may be co-owners of the CPS property. However, there should be a single business entity responsible for legal ownership along with the appropriate contact information to share with the local utility company. In all of the above situations, it is important that all stakeholders understand the legal responsibilities and responsibilities associated with installing CPS in their workplace.

6. Electrical Supply and Metering

There are usually two scenarios for connecting to a commercial electricity supply.

- The first is to utilize an existing main service entrance section (SES) or other suitable supply panel in commercial facilities, and
- The second is to get a new service drop in local electricity utilities.

The decision on which approach to take depends on a number of factors, including the ability to obtain permits from property owners and / or business tenants, the location of existing SES, or adequate electricity supply from the proposed CPS charging station.

If permission is granted from the property owner and/or tenant (as required), then a cost analysis can be performed to compare the cost factors of utilizing an existing supply or a new service drop.

A new utility service connection line will typically require a new customer account be setup, which may include a credit evaluation of the entity applying for the meter, and a monthly meter charge in addition to the energy and demand charges. In addition, the local utility may require an analysis of the anticipated energy consumption in order to justify covering the cost of the new service outage.

7. Nur-Sultan Pilot Installation Cost

Being new and a very small volume, the pilot project incurred higher costs than it would otherwise had the CSP stations been widely installed in greater numbers. By far, the greatest cost incurred was related to wiring. Exhibit 25 shows the cost of the major components for three demonstration sites in Nur-Sultan. This is mostly due to the long lengths of wiring that had to be installed in the retrofit situations. If the CSP was to be installed in brand new buildings, the wiring would have been much less.

Exhibit 25 Nur-Sultan Pilot Project Costs (KZT)

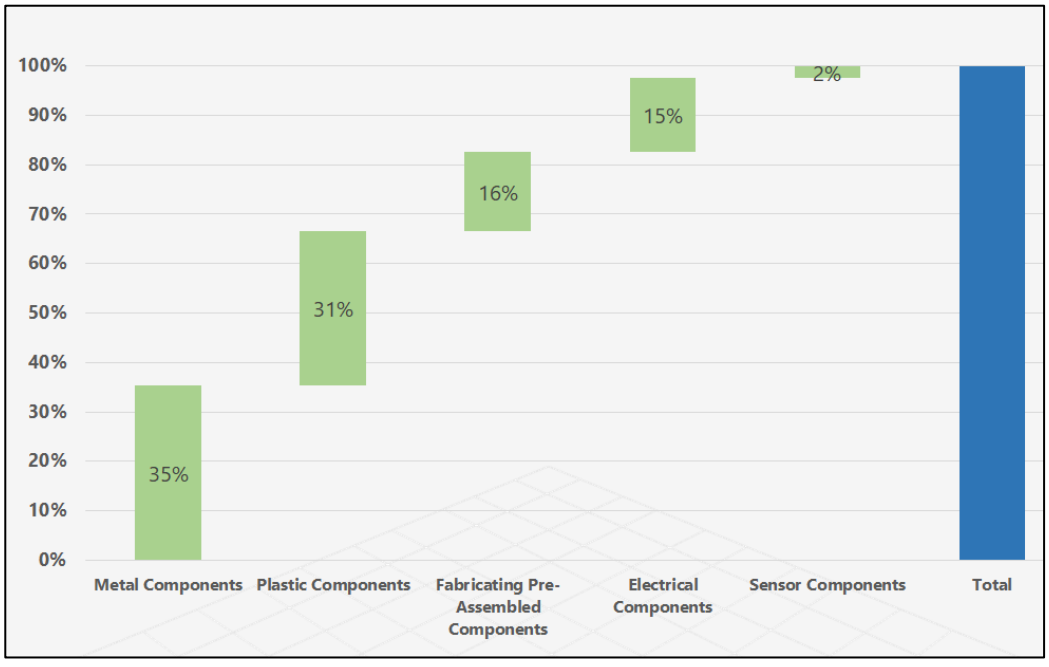
Location	Railway	Yasil Akimat	Saryarka 13 Akimat	*Total*
Number of CPS	8	6	7	*21*
Category 1 - Wire	19238948	3266890	3416920	*25922758*
Category 2 - Trenching	288584	49003	51254	*388841*
Category 3 - Electrical Parts	632692	107435	112369	*852496*
Category 4 - Civil Works	403204	68467	71611	*543282*
Category 5	0	0	0	*0*
Total	20563428	3491795	3652154	*27707377*
Average Cost per CSP	**2570429**	**581965.8**	**521736.3**	***1319399***

8. Assembly and Manufacturing for Kazakhstan

There is an enormous potential for local Kazakhstan manufacturers and assemblers to participate in localization in the block heater supply chain. An analysis was performed on existing BHT components to determine the percent of attributable to different manufacturing processes. As illustrated in Exhibit 26 based on 100% total value added, the breakdown by component is:

- Metal Components 35%,
- Plastic Components 31%,
- Fabrication and Pre-Assembly 16%,
- Electrical Components 15%, and
- Sensor Components 2%.

Exhibit 26 Potential Local Manufacturing Beneficiaries



9. Potential of Using CPS for Electric Vehicle Infrastructure

Although outside the scope of this initiative, the CPS investment can potentially also be leveraged for future in electric vehicles. Most drivers of plug-in electric vehicles (PEVs) charge their vehicles overnight at home using AC Level 1 or in some cases, AC Level 2 charging equipment.

As a rule of thumb, Level 1 Charging enables 3-8 kilometers driving range per 1 hour of charging. The CPS infrastructure can also be used for Level 1 electric vehicle charging. It requires a 220V outlet available, such as while charging at home, but can easily provide charging for all of a driver's needs. For example, 8 hours of charging at 220V can replenish about 65 km of electric range for a mid-size electric vehicle.

The charging equipment is often installed in garages; however, outdoor installation and use are also safe, even if the vehicle is being exposed to rain. Outdoor installations require outdoor-rated charging equipment, and this would already apply to the CPS equipment.

As with electric vehicles, the charging station ownership or block heater charging pile would typically fall into one of two categories:

- Owned by the site host are purchased, installed, and maintained by the site host. This allows for full control over the CPS and the ability to keep all revenue from the station. Under this model, the site host would be responsible for all associated costs, including any maintenance or payment transaction fees.

- Site host-owned or third party-owned, such as a commercially branded charging network. (e.g., owned by a charging network), though there are other possible arrangements. Common pricing structures include by kWh, by session, by length of time, or through a subscription. The third party would be responsible for installation and maintenance. This minimizes responsibility to the site host, and in some cases, the site host may also earn revenue by leasing the space occupied by the CPS to the third party.

Charging at a multi-family residential complex requires additional considerations and may be more like public charging than charging at a single-family home. PEV charging stations for multi-residential buildings, such as condos or apartments, provide property owners with a unique way to help attract and retain residents and foster an environmentally sustainable community. Multi-residential owners face unique considerations when installing charging stations, ranging from parking and electrical service access to billing and legal concerns.

X. BLOCK HEATER TECHNOLOGY FUNDAMENTALS

1. What is a Block Heater?

An engine block heater is useful to car owners living in climates with very cold winters. The first time a driver starts a car on a cold morning is when lots of engine damage can happen as shown in Exhibit 27. To prevent that, the block heater warms the engine's oil or coolant to make starting easier and prevent start-up damage.

When temperatures are below 0°C, the engine oil becomes thick. Thick, cold oil makes the engine's starter work harder, resulting in long cranking times. This can quickly deplete the battery, especially if the battery is old. Cold temperatures make starting a car more difficult for the electrical system. An engine block heater can prevent the battery from needing to get an external battery boost. An engine has small passages that allow the oil to lubricate critical parts. Cold oil does not flow into the small passages, allowing metal parts to rub against each other.

Exhibit 27 Example of Astana Taxi Block Heater Pilot Participant

Drivers living and driving in cold climates that have noticed the cars being more difficult to start on really cold mornings may want to consider buying and installing an engine block heater. Older, higher-mileage vehicles and trucks with large, low-compression engines can reduce start-up damage and improve start-up emissions too.

Cold temperatures can cause different metals in the engine to become tighter. Tighter clearances mean more friction. Some engine builders state that as much as 75% of the damage done to an engine happens at start-up. Metals also become more brittle when cold, so the chance a worn part may break is greater when it is cold. The car’s electrical system is even impacted by cold temperatures.

When the engine starts, the oil pressure is low. In extreme cold, the oil may not lubricate critical bearings and can cause scoring and damage to difficult to replace parts, such as this crankshaft. Car batteries are less efficient when cold and can easily become discharged trying to start a freezing cold engine. Whether a block heater is worth it depends largely on where a driver lives and the climate they drive the vehicle in. It is a good idea to equip the car with one if the driver frequently needs to drive the car or truck when it is very cold.

Engine block heaters that warm the engine coolant are effective at improving the warm-up of the car or truck cabin heater. It can also be useful for drivers that want the inside of the car to warm up quicker than usual. A block heater used with a remote starting system can be an excellent option for drivers living in cold climates.

Most people will plug the block heater in when they go to sleep for the night. Turning on an engine block heater four hours using a timer before the driver needs to drive will prevent cold oil and coolant from damaging the engine. Research has demonstrated that a block heater is only effective at raising temperatures for about four hours. After that, the increase in temperature is a lot less significant.

Automobile manufacturers that build specialty vehicles intended for use in the extreme cold often equip the vehicles with OEM models installed straight from the factory. However, most cars and trucks owners will need to install an aftermarket block heater.

2. Class of Block Heaters

The types of block heaters available are:

- Oil Pan Heater – These attach with magnets to the engine oil pan and heat the oil, but not the engine coolant.

- Engine Warming Blanket – These are like an electric blanket and are usually draped or wrapped around the engine when in use.

- Inline Coolant Heater – These can be installed in the lower radiator hose or in a heater hose and work by heating and circulating coolant.

- Freeze Plug Heater – When most people refer to a block heater, this is the device they are referencing. These replace a freeze plug with a heating element. A 120/220V AC plug hanging from the grill of the vehicle is a dead give-away that the vehicle is equipped with one.

- Bolt-on Heater – On some vehicles, one of the cylinder head bolts can be replaced with a hollow shaft that houses an electric heating element. These are more common in industrial equipment and vintage vehicles.

3. Benefits of a Block Heater

When temperatures plunge below freezing, the engine might have difficulties starting without some aid. Sometimes that help comes from block heaters. These engine heating systems are a perfect investment to boost the lifespan of the car and to make sure it is set to operate at all times. The benefits of installing and using the engine block heater include:

Minimizes stress to the engine, starter motor, battery among other engine components. Starting the vehicle's engine when it is freezing usually strains the engine. During cold spells, the car's oil becomes thick leading to a number of unfavorable side effects. First, the amount of work needed to turn the crank engine by the starter increases when the oil is thicker than normal. This leads to extended starting times of the vehicle. Second, thicker oil cannot shoot through all the channels of the engine to lubricate crucial components. Consequently, when the driver starts the engine, those components rub against one another without any lubrication. This phenomenon causes additional wear and tear on the engine. In turn this usually results in damage and premature repairs to the engine. In addition, if the engine of the vehicle is running with cold components that have not warmed and expanded to the appropriate size, they can end up being damaged.

Starting becomes difficult, and this wears out the engine parts. Moreover, it harms not only the engine but also the starter motor and battery. Using a block heater warms up the cabin of the vehicle faster. Those initial few seconds within a cold car can be just as stressing as they are for the car. When heating the engine coolant fluid using a block heater, the vehicle's cabin can

suck in heated air almost right away after starting it in the morning. The block heater only requires four hours to heat the engine prior to starting it. Current engine block heaters make it possible to install timers on them.

a. Saves Fuel

In most cases, the block heater will save 15 to 30 % of fuel during the initial 10 km of driving if it is installed an engine block heater in the vehicle. As a general rule, the larger is the engine, the greater the savings by using a block heater.

b. Benefits for The Environment

Since the use of a block heater enables cold-weather starting and quickens cabin warming, it as well reduces the emission of greenhouse gases and volatile organic compounds (VOC)

- One-sixth the amount of carbon monoxide
- One-fifteenth the quantity of hydrocarbons
- One-quarter as much nitrous oxide it would produce if not fitted with a block heater

4. Selecting a Block Heater

The best type of engine heater depends on a number of factors.

Inline coolant heaters are most useful for drivers who live in regions where oil is likely to remain viscous, but freezing temperatures may cause water in the engine to freeze. These are particularly effective for getting a car's heater producing warm air faster.

An engine warming blanket is most useful for drivers that do not regularly encounter below-freezing conditions but may a few times a year. These are the simplest form of engine block heaters but are also the least efficient ones.

The most common and efficient heaters are those that heat the coolant. Installing these heaters is not difficult for most average mechanic. Block heaters that install in the lower radiator hose or in one of the engine freeze plugs will require the installer to drain the vehicle's coolant and refill it afterward. This is also a good time to make sure the mixture of the coolant is correct to prevent freezing the water in the engine.

The cord of the block heater cord at times hangs out of the grille of the car, but it is sometimes located inside the hood. The cable plugs into an exterior extension cord, which the driver consequently connects into an electrical outlet. However, it might be difficult to see and locate the block heater cord. This is because newer vehicles have a covering for the electrical prongs to improve on the safety of the cord.

a. Bolt on engine heater

The heater functions by heating the entire engine by direct contact. Though effective, a bolt-on heater heats the engine wholly and not the coolant directly.

b. In-Line Coolant Heater

The design of an in-line coolant heater enables it to maintain the coolant above a specific temperature to keep in a fluid state. This engine heating system is pump-driven, continually moving around the heated coolant to prevent it from thickening due to cold. An in-line heater is, basically, a heater that the mechanic should install in line with the engine's coolant circulatory system. In simple terms, it is a heater has the greatest flexibility for positioning as it would fit it near the thermostat or at the output of the radiator. The mechanic can slit a segment of any

coolant hose on the car and join both ends of the hose to the input and output of the heater. The coolant will flow through the heater where it will be heated up.

c. Oil Pan Heater

This type of block heaters entails a plastic pad which encases a heating element. It can be attached to the oil pan heater, and it will warm up everything that is within. Thought the engine oil pan is the most favorite spot, the mechanic can as well install the block heater on the transmission oil pan. Pre-heating the transmission oil can assist with a hard shift during cold weather. It will as well minimize the overall wear and tear on the components of the transmission due to cold start. Oil require more time to warm up, and transmitting the heat to the oil pan from the heater and eventually to the oil consumes more energy as well.

d. Freeze Plug Heaters

A freeze plug heater is relatively smaller than the oil pan heater. It is a simpler gadget for protecting the vehicle's engine from extreme cold. They are block heaters that the mechanic installs directly on the engine block of the vehicle, as a substitute to one of the freeze plugs. These plugs role is to prevent the vehicle's engine from cracking. They achieve this by popping out if, due to some factors, the coolant fluid freezes up within the coolant passages. Freeze plug heater is one of the most efficient types of engine block heaters however; the installation can turn out to be extremely difficult.

e. Drain Plug Heaters

During the installation, drain plug heaters replace the drain plug of the engine block instead of freeze plug as is the case with freeze plug block heaters.

f. Cartridge Heaters

Cartridge heaters are by a greater extent, the easiest engine block heaters to install. The only setback is that the mechanic can only install a single cartridge heater on the vehicle engine block. This is normally on the engine head's side, where the mechanic can glide a cartridge heater and fasten it to a bracket. This way of installation places the heater directly beside one of the channels of the coolant; thereby the coolant will get heated by thermal conduction. The installation of these block heaters take no more than 15 minutes, and they function pretty well as any other engine block heater. However, cartridge heaters tend to cost more than other block heaters.

g. Dipstick Heater

You can temporarily place this type of block heater in the dipstick opening to warm up the air and oil within the crankcase to prevent the thickening of the fluid during cold weather.

5. Engine Block Heater Component Companies

The following list includes companies based in ADB Member countries.

a. Calix AB

Calix AB, based in Sweden, produces products for car heating and battery charging, together with interior car cabin heaters, battery chargers, engine heaters and cables. The company is ISO 14001 and SEMO-certified and has an extensive quality assurance program.

b. DEFA

DEFA is a Norwegian company, founded in 1946. It has more than 400 employees on three continents. DEFA's products and services are distributed in more than 30 countries worldwide. DEFA is one of leading manufacturer of engine heaters and provides customized solutions for most new automobile model on the market.

c. FIBOX

FIBOX, a privately owned Finnish company, is one of the largest enclosure manufacturers in the world, and is the market leader in thermoplastic enclosures used for protecting electrical and electronic components operating in hostile environments. FIBOX enclosures are manufactured in modern factories located in Finland, Germany and Republic of Korea. The enclosures began a new era for Fibox in electrical panel building. Fibox Oy Ab earned the ISO 9001:2000 Quality Certifications for all its operations in 1992. Fibox voluntarily submits its products for third party testing and evaluation, and currently has many third party listings including, UL, FIMKO, DNV, LR, etc. Fibox Enclosures comply with EN 60529.

d. Parking Energy

Established in 2014, Parking Energy is based in Finland. The company develops and operates some of the world's largest EV charging solutions for the real estate sector, enabling all parking bays through an innovative cabling systems and providing charge points as a service

e. Phillips & Temro Industries

Phillips & Temro Industries Ltd. manufactures emission control devices, and diesel engine intake, and exhaust silencing products to the stationary power generation, marine engine, and off-highway industry. The company is based in Winnipeg, Canada. Phillips & Temro Industries Ltd. operates as a subsidiary of Phillips & Temro Industries, Inc. Engine block heaters designed and tested for each individual engine application. Manufactured under the Zerostart / Temro brands, several types of engine block heaters are available to meet your specific needs, including freeze plug heaters, threaded immersion heaters, plate-style heaters and cartridge heaters.

f. Hotstart

Established in 1942, HOTSTART is a Washington state, USA company involved with the design and manufacture of diesel engine heating systems that improve engine and equipment reliability. Employing 200 people, the company makes preheating systems to customers needing easy engine starts, immediate full power and reductions in maintenance, fuel consumption and harmful emissions.

g. Mahle

With over 77,000 employees, Mahle is a German company established in 1920 with a broad portfolio of products and services for the automotive industry. MAHLE is a leading international development partner and supplier to the automotive industry as well as a pioneer for the mobility of the future. MAHLE produces block heater components to continuously optimize the combustion engine.

h. Five Star Manufacturing

Five Star Manufacturing Company, founded in 1948, is a leading manufacturer of cold weather starting aids for large trucks under the Kat's Heaters brand of products. The company focuses on the North American trucking sector for engine heaters and other starting systems.

i. Wolverine Heaters

Wolverine Heaters based in Tennessee, USA manufacture oil pan heaters improved cranking ability and performance even in the most frigid weather (-30°F) while providing the added benefits of reducing fuel usage and equipment wear. Virtually eliminate start up smoke and harmful emissions.

XI. ENGINE BLOCK HEATER INFRASTRUCTURE

Charging pile stations (CPS) are the point of connection to the electrical grid for engine block heater technology (BHT). With the anticipated growth of BHT, the incorporation of electric supply equipment and CPS will become a critical element of city and town planning and designing from a master plan for site-specific installation.

These CPS design guidelines focus on the multi-unit dwellings; publicly accessible locations such as outdoor parking lots, on-street spaces, and highway stops; and private locations including offices and fleet depots which are critical to establishing a full network of charging options.

Expanding the infrastructure network will help make CPS a viable option for all drivers, even those without garages. The benefits come from extended infrastructure networks that are consistent, accessible and easy to use from place to place.

The purpose of these design guidelines is to identify and diagram key siting and design issues that are relevant to local governments as well as developers, homeowners, businesses, utility providers and other organizations interested in best practices for CPS implementation. The guidelines include into two main sections.

1. Site Design

Site-level planning creates the user and public interface for CPS charging. Critical factors in early CPS deployment include the following:

- Accessibility and ease of use
- Visibility
- Safety for installers, users and the public

The guidelines explore communication networks, connection to the grid and user interface, as well as considerations that range from the parking spot up to the urban scale. Every site is unique. These guidelines set out a framework for analyzing site conditions, typical issues and for locating additional resources.

2. Installation

These guidelines present analysis and site design solutions that approach these considerations from the perspective of installation scenarios. Surface lots, on-street parking, parking decks or garages, in-transit and trucking applications comprise the primary installation scenarios that, collectively, cover a majority of potential CPS applications. Siting and installation of CPS will depend on a number of considerations, including: proximity to power supply, parking space size and orientation, pedestrian traffic, lighting and visibility. Many of these considerations are not yet standardized in terms of functionality, and others fall outside the realm of the standards and codes system, such as aesthetics. Each CPS installation will be different, so these guidelines take the important step of establishing baseline considerations that are predicated on a typology of sites.

a. Power Interface Connectivity

The ability to connect to a power source is the top priority for CPS site Design- without power, there is no charge. The CPS's connection to both vehicle and power source occurs across boundaries of ownership and management and includes both the public and private sectors. There is a potentially complex set of relationships and costs, with different aspects of the power connection occurring in one or both of two areas: the public realm, including the public right-of-way, and the private space. These relationships have physical and business implications.

b. Electric Circuit Capacity

Connecting CPS to a power source will require evaluation of existing electrical capacity. This has two parts: the electrical system at the location of the CPS installation, and the capacity of neighborhood systems to support many BHTs charging at once. Electrical cabinets, panels and circuitry will need to accommodate the anticipated additional load.

Utilities will be at the center of discussions of capacity. In addition to ensuring safety where CPS is installed, utilities are concerned with overloading local transformers. Jurisdictions such as Maryland have passed legislation that allows for the disclosure of BHT owner data to utilities, enabling them to plan for neighborhood power needs.

c. Construction Cost

The cost differential for CPS installation is represented by the power interface. Considering a site's power sources and capacity will help plan for lower-cost installations that require less physical construction.

d. Proximity to Power Source

Installing the CPS close to the required power source reduces the need for cutting, trenching and drilling to add new conduits to reach the CPS. Additionally, the cost of installation can be reduced if the existing conduit has adequate capacity for CPS.

e. Billing and Metering

Separate or sub-metering allows electricity used by CPS to be isolated from the rest of a building' or structure's energy usage, though distinguishing usage between multiple cords of a CPS can only be accomplished by the CPS itself. For locations with multiple CPS, it is best practice to separately meter each. Smart meters, through a network connection to the utility, help users and utilities to balance electrical use across peak energy times.

f. Operator Agreements

Different ownership and management structures will determine the degree of difficulty associated with accessing power supply, running conduit and maintaining CPS. The relationship of owners and operators is critical, as different business models will place different requirements on navigating these relationships. The utility will work with the host or operator to bring the power connection to the site.

g. Wayfinding and Signage

Guiding a car to the space is one function of signage, but the parking interface requires clear markings that designate the space for CPS charging only. Markings appearing on the ground similar to striped spaces (reserved for handicapped parking) as well as on vertical surfaces should be used. In addition to standard parking space considerations, when siting CPS, the charging equipment must not interfere with passenger loading and unloading nor impact adjacent traffic.

It is necessary to create spaces and routes that are safe and accessible to drivers of all physical abilities. In general, BHT drivers spend more time than usual maneuvering around a parking space in order to connect and disconnect from the CPS. Accessibility strategies should seek to limit tripping hazards and minimize liability concerns. Wheelchair accessible BHT charging needs a free path from the space to the building entrance.

h. Parking Interface

With regard to parking spaces, BHTs will require certain considerations above and beyond typical design approaches to parking lots and garages. At this scale, the physical requirements take precedence but the user experience must be considered. Cost-adding concerns are largely addressed in the previous section; however, design choices such as canopies, alternative power sources and other extras will add expense. Adding CPS into the typically tight mix of parking lot and garage planning may cost planners and developers some valuable floor area; CPS installation and access can require several extra square meters of space. For safety, extra care in general should be given to placement of electrical equipment in areas that will experience extreme weather or pooling of water.

i. CPS Placement

Site design will specify a mounting approach. Choice of CPS unit design will allow site planners to save space by choosing a configuration that maximizes footprint. Wall or ceiling-mounted products will be appropriate where floor area is at a premium, while charging stations with multiple cord sets will enable one unit to serve multiple spaces.

j. Lighting

Visibility is critical for BHT driver safety and helps to deter vandalism of the equipment. Most parking facilities are designed with lighting that is suitable for CPS installations. Dim lights or cables can create tripping hazards. Lighting upgrades (such as to more sustainable fluorescent lamps) may also present an opportunity to extend wiring for CPS installation.

k. Preventing Vandalism and Power Theft

Public charging carries the possibility of vandalism, metal theft and power theft or unauthorized use. Destruction of property through purposeful defacing of equipment is a possibility. The potential of vandalism and the potential measures taken to minimize it should be considered in every installation situation.

XII. APPENDIX 1 – NUR-SULTAN PARKING LOT SURVEY

A survey of parking lot locations and number of parking spots in Nur-Sultan was conducted in July 2020. As shown in Exhibit 28, there are approximately 42,500 parking spots used for overnight parking and about 39,800 for weekday parking. About 98.5% of the overnight parking spots are free of charge (or included with rent) to use, and only about 1.5% of the total are paid. About 37% of the spots are used during the weekday and are mostly associated with parking at the workplace.

- Overnight parking would be ideal for BHT as it is especially cold early on winter mornings.
- This is followed by Weekday parking spots where the car would be parked for about 7-10 hours before the end of the workday.

Exhibit 28 Parking Spot Primary Occupancy Period

	Free		Paid		Total	
Parking Spot Occupancy Periods	**Locations**	**Parking Spots**	**Locations**	**Parking Spots**	**Locations**	**Parking Spots**
Evenings and Weekends	248	13,765	9	4,256	257	18,021
Overnight	1,957	41,887	15	624	1,972	42,511
Weekday	1,051	37,106	68	2,679	1,119	39,785
Grand Total	**3,256**	**92,758**	**92**	**7,559**	**3,348**	**100,317**

Exhibit 29 shows the predominance of parking spot locations by regional district in Nur-Sultan. Almost 47% of the parking spots are in Yessil District, followed by Almaty District, Saryarka District and Baiqonyr District.

Exhibit 29 Parking Spots by Nur-Sultan District

	Free		Paid		Total	
Nur-Sultan District	**Locations**	**Parking Spots**	**Locations**	**Parking Spots**	**Locations**	**Parking Spots**
Almaty District	705	20,900	9	776	714	21,676
Baiqonyr District	426	10,716	3	430	429	11,146
Saryarka District	1,247	19,516	53	1,033	1,300	20,549
Yessil District	878	41,626	27	5,320	905	46,946
Grand Total	**3,256**	**92,758**	**92**	**7,559**	**3,348**	**100,317**

Exhibit 30 shows the size range and number of parking lot facilities in Nur-Sultan. Parking lot size can range from 1 to 3,420 individual parking spots. For economies of scale and to lower the unit cost of installing charging pile stations, parking lots of between 26-100 parking spot capacity should be prioritized. This would lower the unit cost to obtain permits, perform the individual electric design, construction, commissioning and operating the CPS. To this end, there are approximately 880 parking lots that would fall within this ideal category.

Exhibit 30 Survey Questionnaire for Parking Lot and Parking Garage Operators

	Free		Paid		Total	
Parking Spot Capacity of Parking Lot	**Number of Parking Lot Locations**	**Parking Spots**	**Number of Parking Lot Locations**	**Parking Spots**	**Number of Parking Lot Locations**	**Parking Spots**
1-25	2,301	29,236	54	568	2,355	29,804
26-50	622	22,789	20	728	642	23,517
51-75	139	8,525	6	374	145	8,899
76-100	97	8,593	5	460	102	9,053
101-125	31	3,509			31	3,509
126-150	17	2,387	1	146	18	2,533
151-175	6	960			6	960
176-200	10	1,958			10	1,958
201-225	5	1,077			5	1,077
226-250	3	708	1	250	4	958
251-275	2	513	1	270	3	783
276-300	6	1,769	1	300	7	2,069
301-325	2	638			2	638
326-350	3	1,016			3	1,016
376-400	3	1,183			3	1,183
401-425	1	418			1	418
426-450	1	431			1	431
451-475	1	457			1	457
476-500	1	485	1	500	2	985
501-525	1	513			1	513
526-550			1	543	1	543
626-650	1	640			1	640
1026-1050	1	1,034			1	1,034
1776-1800	1	1,780			1	1,780
2126-2150	1	2,139			1	2,139
3401-3425			1	3,420	1	3,420
Grand Total	**3,256**	**92,758**	**92**	**7,559**	**3,348**	**100,317**

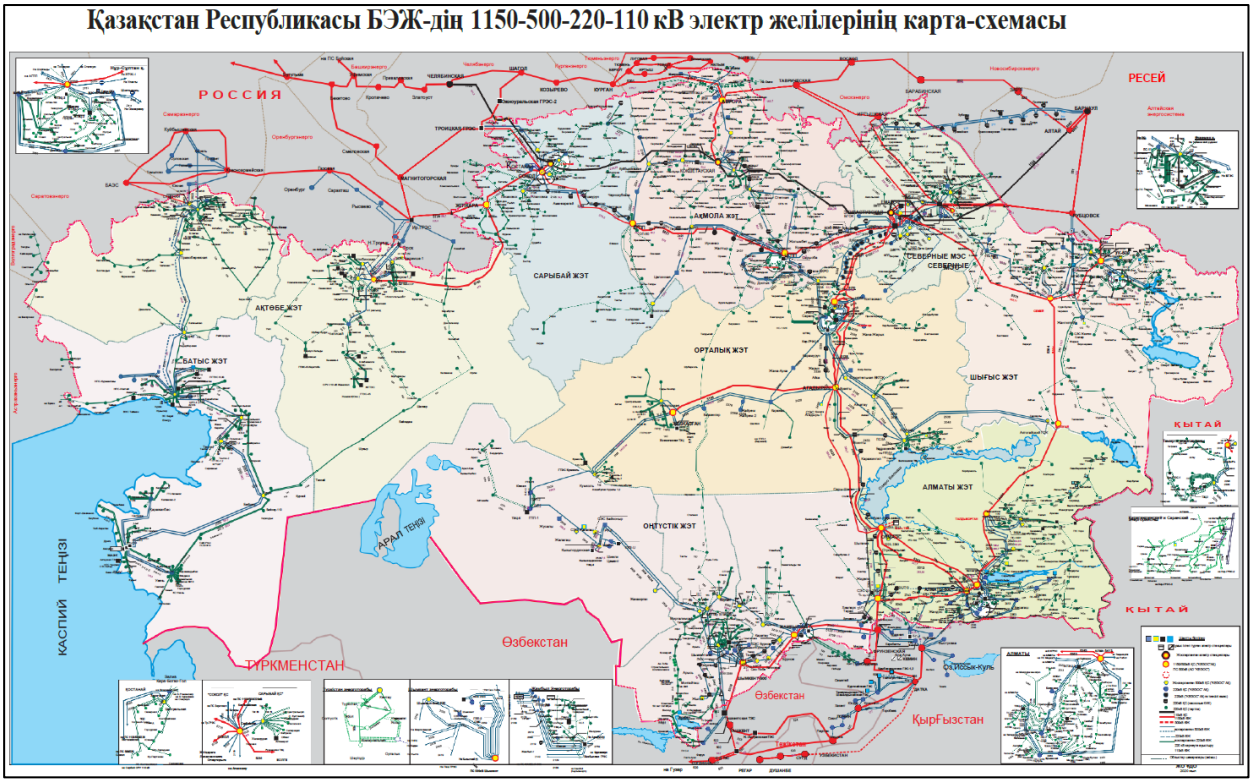
XIII. APPENDIX 2 - KAZAKHSTAN RAILROAD

With headquarters in Nur-Sultan, Kazakhstan Temir Zholy (KTZ) is the national railway company of Kazakhstan. Established in 2002 as a joint stock company, the mission of KTZ is to develop, operate, and maintain railway transportation in Kazakhstan. Kazakhstan's current rail network is based on the legacy from the former Soviet Union, and uses a 1.52 m track gage. The proximity of Kazakhstan provides a smooth transit at international borders to countries of the former Soviet Union. KTZ has approximately 300 TE33A *Kasachstan Temir Scholy* Locomotives as illustrated in Exhibit 31.

Exhibit 31 TE33A Kasachstan Temir Scholy Locomotive

As shown in Exhibit 32, KTZ controls about 15,000 km of track and is the process of modernization and expansion. The Kazakhstan sections of the old Trans-Aral Railway, the Trans-Caspian railway, and the Turkestan-Siberia Railway have been incorporated into KTZ's network.

Exhibit 32 Kazakhstan Railroad Network



It manages over 50,000 state-owned carriages, and about 30,000 private carriages. The majority of hauling is done using diesel engines; however, electrification of Kazakhstan's track is an ongoing project. The transport corridor through Kazakhstan has the potential to provide a railway-ship link between China and the east coast of North America through the Northern East West corridor.

1. Railroad Engine Block Heater Opportunity

As these trains must be ready to go at a moment's notice, it is not unusual for KTZ locomotives to be idling continuously while at a service yard. KTZ has at least 2 recovery trains on "hot standby" through the winter months. These trains are equipped with heavy machinery and passenger carriages for derailment recovery.

Automobiles use a mixture of glycol and water for engine cooling and this permits them to operate a sub-freezing temperatures. By comparison, most train locomotives circulate water within the engine block to cool the engine and damage to the engine can occur when the temperature is below freezing. For this reason, train engines are continuous on idle, not only consuming fuel, but also releasing air emission and noise.

As illustrated in Exhibit 33, most railroad yards also have existing electric power outlets, albeit the units are old and may be in need or servicing or modernization. This existing infrastructure can potentially be used for specialized engine block locomotive engine heaters.

Exhibit 33 KTZ Railroad Electrical Outlets

A typical 2000 kW diesel engine idling at 25% of rated power, as in the case of a train in the yard, will consume about 160 litres of fuel per hour or about 3,880 litres per day. The corresponding daily CO2 emissions would be approximately 10,250 kg. Block heater technology also exists for large diesel engines and if applied for KTZ's engine fleet would result in considerable fuel and cost savings, reduced engine maintenance, and reduced CO2 and particulate emissions.

XIV. APPENDIX 3 – BUSINESS FAIR

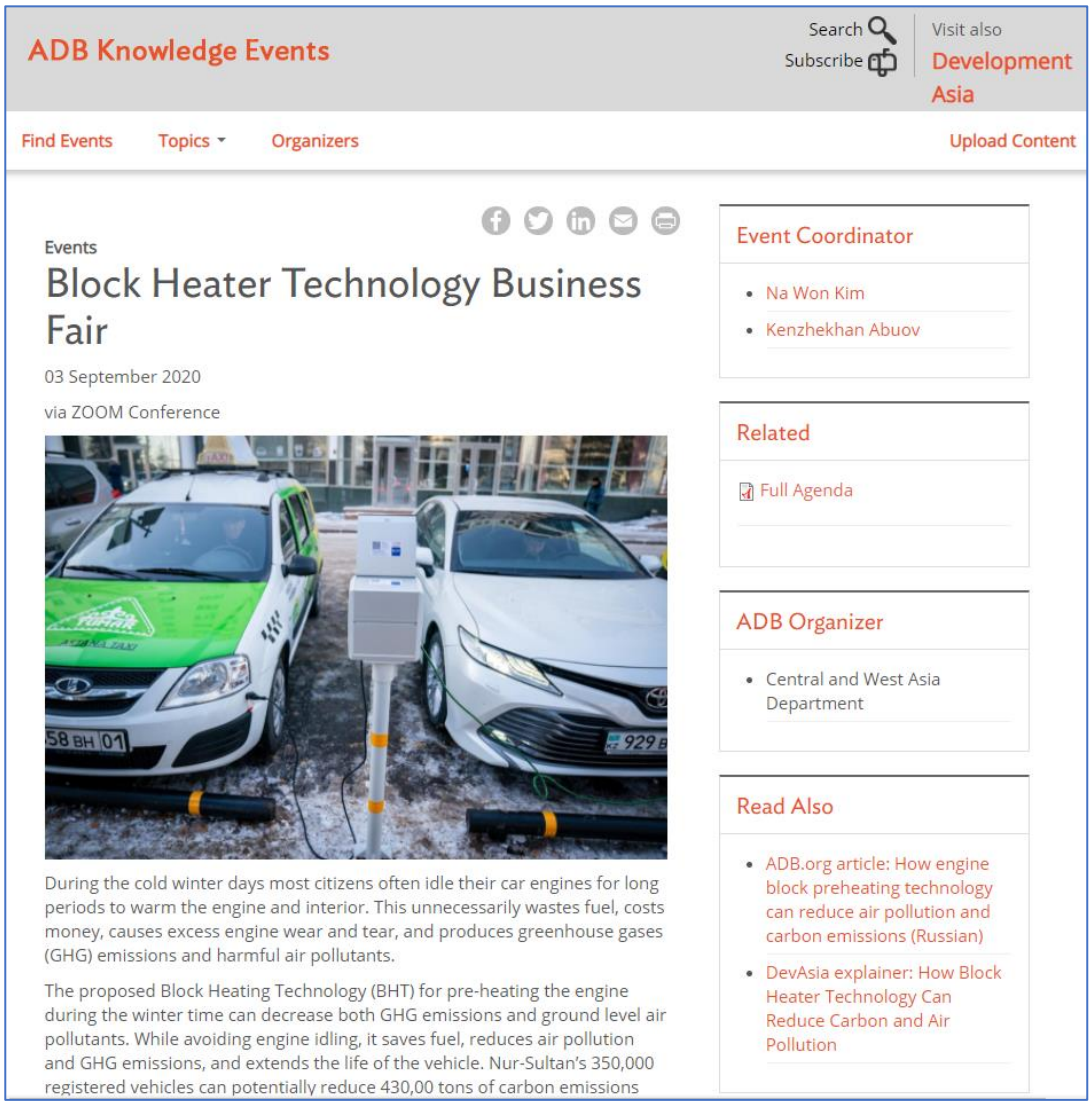
A virtual Business Fair was held on September 3, 2020 and included local and international participants including diplomats, government agencies, economic development, environmental stakeholders, manufacturers, service providers and supply chain.

The themes of the business fair included:

- Session I: Introduction
- Session II: Overview on Promoting Low-Carbon Development in Nur-Sultan and Kazakhstan
- Session III: Future of Technology Transfer
- Session IV: Technology Deployment in Nur-Sultan
- Session V: Localization of Technology in Nur-Sultan
- Session VI: Wrap-Up

For wider dissemination of block heater technology (see Exhibit 34) English and Russian presentations delivered at the Business Fair were posted on the ADB Knowledge Events website: https://events.development.asia/learning-events/block-heater-technology-business-fair (Web Link Validated October 2020)

Exhibit 34 Website with Proceedings of Block Heater Business Fair



XV. APPENDIX 4 – ULAANBAATAR POTENTIAL

Mongolia was another potential beneficiary of this Regional Technical Assistance on Low-Carbon Development in CAREC. Exhibit 35 shows a similar but colder winter season for Ulaanbaatar Mongolia. This city can experience even more bitterly cold winter days than Nur-Sultan. Taking into consideration the PM2.5 level of ground pollution (Exhibit 36), the situation for Ulaanbaatar's air quality is far worse and this situation repeats over and over each winter season. It is recommended that ADB continues with more detailed analysis for BHT in the case of Ulaanbaatar.

Exhibit 35 Temperature Range for Ulaanbaatar, MON 2000-2019

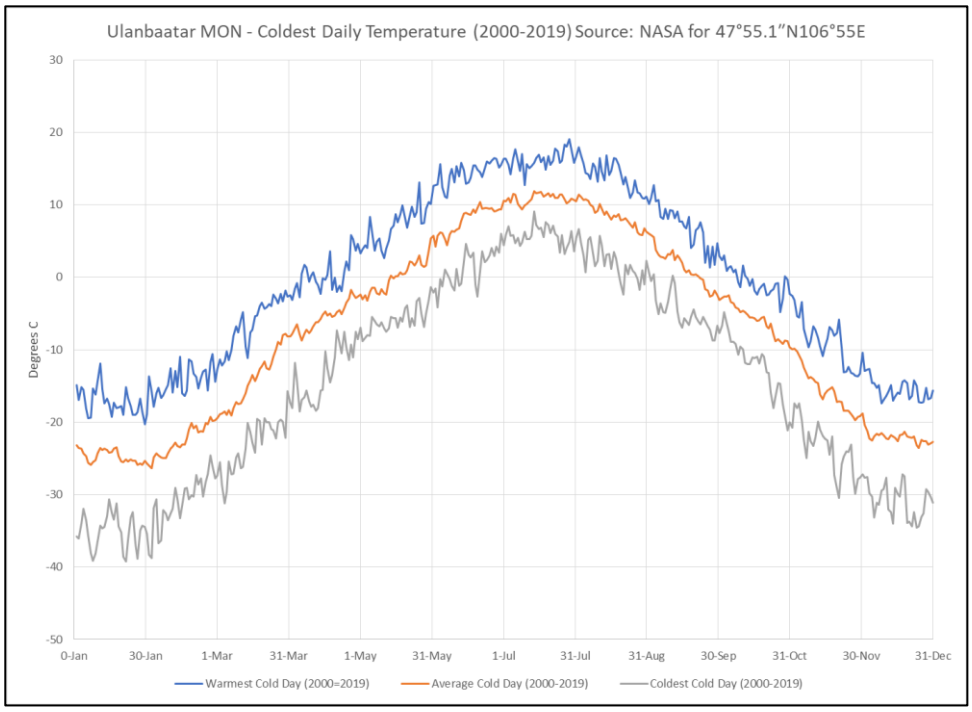


Exhibit 36 PM 2.5 Level of Ground Pollution for Ulaanbaatar, MON 2016-2020