Data Article

Spatial electricity market data for the power system of Kazakhstan

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Abstract

The data presented in this article are related to the research article “A spatial electricity market model for the power system: The Kazakhstan case study” (M. Assembayeva et al. 2018). This data article presents information on network topology and characteristics, demand variation and distribution, technical and economic parameters for conventional and renewable generation, as well as availability time series, and imports and exports. The dataset is made publically available to allow for more and independent analysis of this emerging energy market.

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1. Data

This article explains the input data (excel file) which was used for a detailed analysis of the electricity system of [1] and to provide additional information on data acquisition and compilation. A combination of quantitative and qualitative approaches was used in the data analysis of network topology and characteristics, demand variation and distribution, technical and economic parameters for conventional and renewable generation, as well as availability time series, and imports and exports.

The data file has five spreadsheets and is structured as follows: The spreadsheet General Information contains definitions of sets with a short description and information on related entries as well as a list of network nodes with additional information. The spreadsheet LINES contains technical parameters of the individual network lines and the network topology based on [2–4]. The spreadsheet DEMAND contains hourly electricity demand data for a winter and a summer week in Kazakhstan, allocated to the nodes defined on the General Information spreadsheet with data based on [5–8]; import and export flow are also reported here. The spreadsheet PLANTS lists power plants on the block level and their main technical and economic characteristics based on data from Refs. [9–13]. The spreadsheet PV_WP provide corresponding regional time series for the availability of wind and PV energy sources based on data from Refs. [14,15].

2. Experimental design, material and methods

2.1. Data of Kazakhstan’s transmission system

Data on Kazakhstan’s transmission system in spreadsheet LINES depicts the state of the system in 2015. It includes details on the location of the substations and the topology and technical parameters for the high-voltage transmissions lines. Fig. 1 presents the topology of the grid of Kazakhstan.
Fig. 1. Electricity map of Kazakhstan (2015). Source: Own figure based on [1].
According to the data provided by the transmission system operator KEGOC and verified in individual desk research to identify location and interlinkage in the system. The country’s high voltage transmission system consists of 310 lines (35–1150kV). The dataset provides information on 193 lines, as it only considers the range of 220–1150 kV plus some additional 110 kV lines to specify the representation of flows in the region of Almaty and Atyrau. The 1150 kV lines are now operated as 500 kV lines. Each line is identified through a unique identifier referring to its voltage level and its location.

Table 1
Calculated nodal demand for 2013.

| Node  | Region           | Residential demand | Industry demand       | Substation       | Annual nodal demand [TWh] |
|-------|------------------|--------------------|-----------------------|------------------|---------------------------|
| N0000 | Akmola           | Kokshetau          |                       |                  | 1150 Kokshetauskaya       | 0.73                      |
| N0001 | Akmola           | Astana             |                       | NC KTZH JSC      | 500 CGPP                  | 5.13                      |
| N0007 | North Kazakhstan | Petropavlovsk      |                       |                  |                           | 3.38                      |
| N1002 | West Kazakhstan  | Uralsk             |                       |                  | 220 ”Uralskaya”           | 1.66                      |
| N1003 | Aktobe           | Akto 7            |                       | AZF TKN Kazchrome JSC (Akto) | 220 “Aktyubinskaya” | 3.94                      |
| N2004 | Almaty           | Almaty             |                       | NC KTZH JSC      |                           | 220 Robot                 | 0.12                      |
| N2008 | Almaty           | Almaty             |                       |                  | 220 Taugul                | 0.62                      |
| N2009 | Almaty           | Almaty             |                       |                  | 220 Eremensay             | 1.86                      |
| N2011 | Almaty           | Almaty             |                       |                  | 220 SS#7                  | 0.41                      |
| N2012 | Almaty           | Almaty             |                       |                  | 2.89                      |
| N2013 | Almaty           | Almaty             |                       |                  | 3.09                      |
| N2014 | Almaty           | Taldykorgan        |                       |                  | 0.79                      |
| N3002 | East Kazakhstan  | 1150 Kuncogorsk     |                       | KazZinc LLP, UK TMK JSC (Ust-Kamenogorsk titanium and magnesium plant) | 220 #7 | 8.63                      |
| N4000 | Mangystau        | Zhanaozhen         |                       |                  |                           | 1.62                      |
| N4001 | Mangystau        | Aktau              |                       |                  |                           | 2.84                      |
| N4003 | Atyrau           | Atyrau             |                       | Tengizchevoi LLP | 220 Tengiz                | 2.28                      |
| N4004 | Atyrau           | Atyrau             |                       |                  | 162                      |
| N5000 | Kostanay         | Kostanay           |                       | NC KTZH JSC      | 1151 ”Kostanaikskaya”     | 2.10                      |
| N5001 | Kostanay         | Rudnyi             |                       | Sokolov-Sarybai Mining Production Association (SSGPO) JSC | 500 ”Sokol” | 3.43                      |
| N6000 | Pavlodar         | Ekibastuz e        |                       | NC KTZH JSC      | 1150 “Ekibastuzskaya”     | 2.18                      |
| N6001 | Pavlodar         | Pavlodar           |                       | Pavlodar Aluminum Plant JSC, Kazakhstan electrolysis plant JSC, Aksu Ferroalloy Plant JSC | 220 EEE - Aksu, AZF | 15.35                      |
| N7004 | Karaganda        | Karaganda          |                       | Arselor Mittal Temiratull JSC |                       | 3.86                      |
| N7005 | Karaganda        | Karaganda          |                       | K. Satpayev channel RGP |                       | 5.05                      |
| N7006 | Karaganda        | Karaganda          |                       | NC KTZH JSC      |                           | 0.91                      |
| N7008 | Karaganda        | Balchash           |                       | Corporation Kazakhmys LLP Balchash |                       | 1.40                      |
| N7010 | Karaganda        | Zhezkazgan         |                       | Corporation Kazakhmys LLP Zhezkazgan |                       | 2.38                      |
| N7012 | Karaganda        | Temirtau           |                       | Taraz Metallurgical Plant LLP, Kazphosphate LLP | 500 Zhambyl (Taraz) | 3.49                      |
| N8000 | Zhambyl          | Taraz              |                       | Taraz Metallurgical Plant LLP, Kazphosphate LLP |                   |                           |
| N8005 | South Kazakhstan | Turkestan          |                       | 220 Mergtailsay   | 0.63                      |
| N8008 | South Kazakhstan | Shymkent           |                       | NC KTZH JSC      |                           | 3.36                      |
| N8010 | Atyrau           | Kyzyorda           |                       |                 |                           | 1.20                      |
| N8012 | Atyrau           | Baykonur           |                       | KyzyOrda         | 0.28                      |
| N8014 | Zhambyl          | NC KTZH JSC      |                       | Chu 500          | 0.17                      |

*NC KTZH JSC - National Company Kazakhstan Temir Zholy JSC — demand is adjusted by regions according to the data of railway electrification.*

According to the data provided by the transmission system operator KEGOC and verified in individual desk research to identify location and interlinkage in the system. The country’s high voltage transmission system consists of 310 lines (35–1150kV). The dataset provides information on 193 lines, as it only considers the range of 220–1150 kV plus some additional 110 kV lines to specify the representation of flows in the region of Almaty and Atyrau. The 1150 kV lines are now operated as 500 kV lines. Each line is identified through a unique identifier referring to its voltage level and its location.
Fig. 2. Conventional and renewable power plants capacity in Kazakhstan in 2015. Source: Own figure based on [1].
Technical characteristics of the transmission lines included in the dataset such as voltage level, number of circuits, thermal power flow limits, and loss factors have been taken [2–4]. The line length is calculated based on geo-information on the substations using qgis.

2.2. Data on electricity demand

Nodal hourly demand data for one summer and one winter week is reported in the spreadsheet DEMAND. The respective values are derived as follows:

1) Two types of electricity demand are considered: residential and industrial
2) Annual Industrial demand for 2015 is known for the 15 biggest companies [7]. Their demand is allocated to the closest substation and assumed to have a flat profile.
3) Residential demand is distributed to 24 residential centers (cities with a population above 70,000) according to population statistics [8].
4) Residential demand is assumed to fill the gap between industrial demand and data on the hourly national demand profile for 2013 [5]. The national demand profile is distributed to the regional level using [5]. The resulting demand levels are given in Table 1.
5) To arrive at final values for 2015, residential demand is scaled up so that total regional demand matches figure reported for 2015 in Ref. [7].

2.3. Data on electricity generation units

The spreadsheet PLANTS provides information about generation capacities on the unit level: geographical location, fuel type, combined heat and power (CHP) ability, year of installation, net nameplate capacity and efficiency, as well as marginal cost, seasonal minimum load factors, and availability factors. Data on the individual block level was gathered in an individual desk review building on data from Ref. [13]. It is gathered from various sources, translated and verified with experts on the Kazakh electricity system. Fig. 2 shows the location and size of generation capacity in Kazakhstan by generation technology. It highlights the regional differences and provides an intuition about the distribution of resources and natural potentials (coal transports from North to South by rail). Table 2 provides an overview of the data in an aggregated fashion.

For hydropower, seasonal availability factors are calculated based on data provided by Ref. [14]. Time series data for Wind is based on annual generation output of existing units [16] and on historical data on wind speed and solar radiation. To convert to an hourly and nodal

| Fuel | Technology | Purpose | Capacity (MW) | Start year | Average capacity factor (%) | Availability (%) | Average efficiency (%) | Fuel costs (KZT/kWh) |
|------|------------|---------|---------------|------------|----------------------------|------------------|-----------------------|---------------------|
| Coal ST | 663–4000 | 1962–1980 | 65 | 0.8–1.0 | 0.8–1.0 | 32 | 0.3–0.5 |
| Coal ST | 12–1000 | 1937–2009 | 57 | 0.8–1.0 | 0.5–0.8 | 42 | 0.3–2.2 |
| Gas GT | 6–244 | 1996–2012 | 58 | 1.0 | 0.9–1.0 | 33 | 1.8–2.2 |
| Gas ST | 460–1230 | 1983–2006 | 28 | 0.7–1.0 | 0.5–1.0 | 34 | 1.8–2.2 |
| Gas ST | 4–630 | 1944–1981 | 42 | 0.8–1.0 | 0.5–0.9 | 44 | 1.8–2.2 |
| Hydro | 2–702 | 1928–2013 | 33 | 0.3–1.0 | 0.7–1.0 | 93

Source: Own table.

a The capacity factors are calculated based on historical data.
b Availability of the power plant fleet is based on historical data for 2013 and calibrated based on the fuel used (coal, natural gas or oil) and the technology (steam or gas turbine). The main sources were official annual reports of power generation companies.
c Efficiency factors are based on own assumptions based on the age and technology of the unit.
d Fuel prices include fuel and transportation cost and are taken from Refs. [11,12].
wind time series, wind speeds from meteorological stations are transformed using Weibull probability distribution functions. Similarly, data on solar radiation [15] is transformed into a distribution for the network nodes which is then rescaled to an hourly availability between 0 and 1.

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Transparency document

Transparency document associated with this article can be found in the online version at https://doi.org/10.1016/j.dib.2019.103781.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.dib.2019.103781.

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