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A review of current energy systems and green energy potential in Kazakhstan

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ABSTRACT

Kazakhstan is rich in natural resources including coal, oil, natural gas and uranium and has significant renewable potential from wind, solar, hydro-power and biomass. In spite of this, the country is currently dependent upon fossil fuels for power generation. Coal-fired plants account for 75% of total power generation leading to concerns over greenhouse gas emissions and impacts on human health and the environment. Recent economic growth in Kazakhstan has driven increased demand for energy services, making the construction of additional generating capacity necessary for enabling sustained economic growth. In this context, renewable energy resources are becoming an increasingly attractive option to help bridge the demand–supply gap and to decrease national greenhouse gas emissions. This study presents an overview of the existing energy system in Kazakhstan and investigates policy drivers for the energy sector. We review existing studies, national reports, energy strategies and plans, to identify and describe key barriers that prevent diffusion of renewable energy technologies in Kazakhstan. We propose potential measures to overcome specific barriers in order to successfully develop a renewable energy sector in Kazakhstan. It is seen that the likely major contributors to replacing fossil fuel based energy services are likely to be wind power and solar energy technologies, with biomass and hydro energy sources likely to play a lesser role. The barriers to development include low electricity tariffs, transmission losses and inefficient technologies, weak regulatory and legal frameworks and a high-risk business environment.

Contents

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1. Introduction

Kazakhstan emerged from the dissolution of the Soviet Union in 1991 and is currently an upper middle income country of around 17.4 million people [1] spread unevenly over an area of 2.7 million km^2 [2] with 47% of the population living in rural areas [3]. Kazakhstan is located in the centre of the Asian continental land mass and consists of steppe grassland and pastureland in the north, desert and semi-desert in the central and western catchments of the Caspian and Aral Seas and with high mountains in the Tien Shan and Pamir ranges, which are nationally important sources of water, fringing the south of the country. Agricultural land comprises 76.5 million hectares with 61% permanent pastures and 32% arable land producing grain and livestock [4]. The climate of Kazakhstan is continental [5], characterized by intensely cold winters with January air temperatures ranging from −18.5 °C, in the north of the country, to −1.8 °C in the south, and hot summers with July air temperatures ranging from 19.4 °C in the north to 28.4 °C in the south [6]. Energy consumption reflects the impact of the challenging continental climate with harsh winters necessitating space heating and hot summers air conditioning, which places an increasing demand on power supplies.

Kazakhstan's economy benefits from its natural resources (particularly oil, gas and uranium), heavy industry (ferrous and non-ferrous metals) and agricultural sectors. The petroleum and mining industries accounted for 33% of GDP in 2010 and 82% of exports [7]. GDP increased from 16.9 billion USD in 1999 to 224.4 billion USD in 2013 [8]. Since 2000, the GDP growth rate of Kazakhstan has varied between 6.5 and 9%, as shown in Fig. 1 [8]. The favourable economic environment and rapid per capita income growth contributed to an impressive reduction in poverty from 47% of the total population living in poverty in 2001 to 3% in 2013 [8]. However, in common with many developing countries, rapid economic growth in the past decade has led to a sharp upswing in electricity consumption; power shortages in the winter periods where demand on electric loads has necessitated restrictions on consumption have had an adverse impact on regional economic development [9]. Primary energy consumption has risen from 26.92 Mtoe in 1999 to 82.03 Mtoe in 2013 [9] while total annual power generation has increased from 45 TWh in 1999 to 91 TWh in 2013 as can be seen in Figs. 2 and 3 [10]. The total installed capacity is 19.8 GW [11], while the available capacity is about 15 GW [12] principally due to aging equipment and lack of maintenance [13]. Approximately 10% of Kazakhstan's power is generated by hydroelectric power stations along the Irtysh River, whilst 90% is from thermal-powered plants (75% coal-fired stations and 15% gas-fired plants), as presented in Figs. 4 and 5 [14]. Renewable sources such as wind, solar, small hydro and bioenergy currently contribute less than 1% of Kazakhstan's energy mix [15] however there is considerable potential in renewable power generation and the government expects the total share of renewable power generation to rise to 11% by 2030 with 1040 MW of renewable energy capacity by 2020 [11].

80% of total electricity is produced in the industrial north by power plants located near coal mines [12] however electricity transmission networks across the country are inefficient with losses during transmission and distribution estimated at approximately 15% of energy produced, although the actual value may be higher [11]. As presented in Fig. 6, the electricity transmission and distribution system is divided into three networks with two in the north connected to Russia, and one in the south connected to the Unified Energy System of Central Asia [12]. Growth in the demand for electricity is forecast to reach between 120 and 180 TWh by 2030, as depicted in Fig. 7 [16]. Given Kazakhstan's rapid economic development and the associated increasing electricity demand, significant modernisation of existing power facilities in addition to construction of new power generation plants of ~20 GW is needed by 2020 [16]. Improving energy efficiency is also important; a recent study demonstrated that improving the efficiency of electricity and heat systems can cut almost one third of electricity and

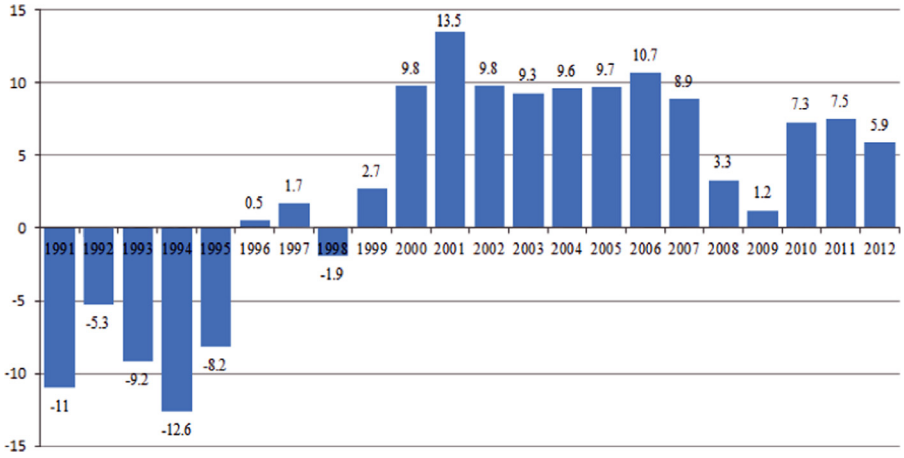

Fig. 1. Kazakhstani GDP growth (annual %, 1990=100%) [8].