International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2021, 11(3), 269-279.

Analysis of Green Technology Development in Kazakhstan

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Received: 22 November 2020 **Accepted:** 02 February 2021 **DOI:** https://doi.org/10.32479/ijeep.10897

ABSTRACT

Although Kazakhstan is a fossil fuel rich country, policymakers desire to develop a green and sustainable economy and to contribute to the global energy transition. To understand the overall situation in green technology development in the industrial sector, we conducted the first countrywide study in Kazakhstan. In this paper, we present the results of the large survey on the use of "green technologies" by industrial companies in every region of the country. We aggregate the 380 reported cases of the use of green technologies by sectors like energy production, waste management, and others. We found the largest number of cases accumulated in the waste management sector, and the smallest in green building construction. Our work shows that only 266 out of 877 (~30%) industrial organizations in Kazakhstan utilize some form of green technology. Based on detailed analysis of 141 organizations, the Karagandy, East Kazakhstan, Aktobe, and Atyrau regions reported the largest number of applications of green technologies among the 17 administrative-territorial units of Kazakhstan. We also discuss barriers to the diffusion of clean technologies. We believe that this work will be of interest to politicians, environmentalists, and practitioners who are concerned about the impacts of global warming.

Keywords: Clean Technologies, Sustainability, Green Economy, Energy Transition, Power Sector, Climate Change
JEL Classifications: Q01, Q2, Q53, Q55, Q56, O33

1. INTRODUCTION

Global warming is one of the most important problems facing the world today. The impacts of "Global Warming of 1.5°C above pre-industrial levels" (IPCC Report, 2018) have been discussed thoroughly in the literature. For example, (González-Mahecha et al., 2019) estimate that up to 16% of active power plants in Latin America and the Caribbean (LAC) should be closed to meet carbon budgets. On the one hand, the existing coal-fired power plants are getting old (retirement); on the other hand, the electricity consumption (demand) is increasing worldwide. In the US, the gap will be closed by natural gas, nuclear, and renewable sources of energy (Clemmer et al., 2013). Germany is likely to use coal-fired power plants until 2038 (Rinscheid and Wüstenhagen, 2019). The "capital costs and carbon policy" are the most dominant factors for increasing the wind and solar share in the electricity generation mix in the US (Bistline and Young, 2019). It is important to develop attractive tax credits for investors to make clean technologies more competitive economically. Examples of green (or, clean, sustainable) technologies include more efficient reduction of CO_2 emissions (by 20-25%) and energy consumption (by 18-31%) in metallurgical plants through electrolysis (Dudin et al., 2017), and a better use of energy (Sheppard and Rahimifard, 2019) and production packaging (Joachimiak-Lechman et al., 2019) in food manufacturing. There are many approaches for reducing greenhouse gas (GHG) emissions and developing a sustainable future, but ambitious climate goals need the active involvement of governmental policymakers.

Kazakhstan is an upper-middle-income country located in the Central Asian region with a gross national income per capita of US$ 8,810 in 2019 (World Bank, Countries, 2020). The country has experienced considerable economic growth in the last two decades, but its development pathway can hardly be considered as 'green'. As a result of the poor management of its significant natural resources the country experienced many years of environmental degradation (Russell et al., 2018). The emissions intensity of the Kazakhstan economy remains to be one of the highest in the world: the carbon intensity of the gross domestic product (GDP) in Kazakhstan (0.6 kg per purchasing power parity (PPP) $ of GDP in 2016) is 2 times higher than the world average (0.33 kg per PPP $ of GDP) and 3 times higher than the European Union's (0.2 kg per PPP $ of GDP) (World Bank, CO_2 Emissions, 2020). Major cities in Kazakhstan suffer from heavy air pollution; with the concentrations of pollutants in the air exceeding the European Union's annual limit values in ten of the eleven studied cities (World Bank, Towards Cleaner Industry, 2013).

Kazakhstan adopted a strategic document as a Concept of the transition to a green economy (Strategy 2050, 2013) (Green Economy Concept, 2013) immediately after the Rio+20 World Summit (Rio+20 Conference, 2012). The country has made some progress (Soltangazinov et al., 2019) in the area of regulatory reform in support of the Concept, including the development of Kazakhstan's Environmental Code (an ongoing process with regular improvements), energy efficiency, and renewable energy policies. One example of this effort is the 2020 construction of a gas pipeline – 1,081 km between Karaozek, Zhezkazgan, Karagandy, and Nur-Sultan – from South-West Kazakhstan to the central part of the country with the aim to reduce the use of coal in nearly 2.7 million households for heating, which was 40% in 2011-2013 (Kerimray et al., 2018). Besides that, two coal-fired thermal power plants in the city of Nur-Sultan will be converted to natural gas by the end of 2021. Thus, there has been the introduction of green technologies, or cleaner production as defined in (Hilson, 2000), and aspects of the green economy are becoming not just a popular trend, but also a system for ensuring the survival of humankind through achieving sustainable development.

Figure 1 illustrates the share of electricity produced by renewable energy sources (the orange bar for all RES, with the left side axis in 1000 kWh) in the total electricity production in Kazakhstan (represented by the grey shaded background, with the right side axis in 1000 kWh) according to data from the Statistics Committee of the Ministry of National Economy of the Republic of Kazakhstan. The share increases from 9.1% in 2011 to 10.4% in 2019, with electricity produced by hydroelectric power plants (HPP) – including large (i.e., > 35MWt) plants – in the amount of 9,993,658.8 thousand kWh, wind farms (707,135.1 thousand kWh), solar power plants (391,229.6 thousand kWh), and biogas plants (4,967.1 thousand kWh) totaling 11,096,990.6 thousand kWh. The rest of the electricity was produced by coal-fired power plants (70.25% on average for 2011-2019, with standard deviation of 2.58%), thermal power plants (TPP) on gas (μ = 12.14%, σ = 0.82%), TPP on fuel oil (μ = 0.02%, σ = 0.02%), and gas turbine power plants (μ = 7.61%, σ = 0.81%). Many enterprises install solar panels and wind generators for their own needs, through which they reduce GHG emissions, reduce the use of carbon fuel, and, at the same time, receive economic benefits in the form of reduced costs for electricity payments.

Between 1990 and 1999, due to the economic recession in Kazakhstan, GHG emissions decreased by nearly twofold, from 401.9 million tons in 1990, reaching its minimum of 203.7 million tons in 1999, followed by a gradual increase over the following years (2000 to 2018), as seen in Figure 2 (UNFCCC, 2020). In

Figure 1: Electricity production in Kazakhstan in 2011-2019 by types of RES: hydro, wind, solar, and biogas

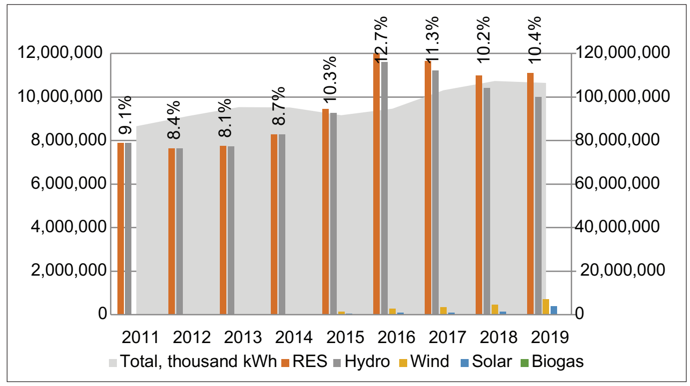


Figure 2: GHG emissions trends in Kazakhstan between 1990 and 2018 by sources[1], in 1000s of tons (excluding emissions from land use, land use change, and forestry)

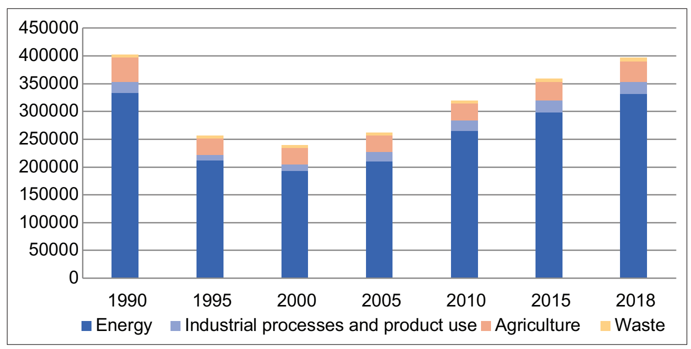
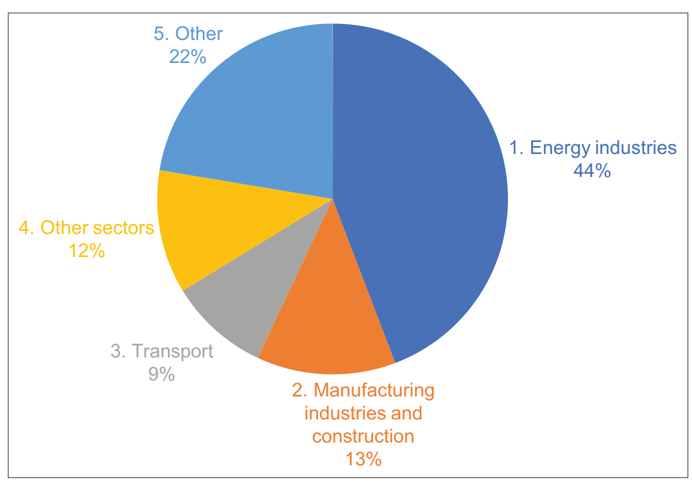


Figure 3: Share of emissions in the "Energy" Sector by sub-sectors in 2018



1 Energy sector includes energy industries, manufacturing industries and construction, transport, and other sectors, as well as fugitive emissions from fuels.

2018, GHG emissions in Kazakhstan amounted to 396.6 million tons, nearly reaching its 1990 level, as seen in Figure 3 (UNFCCC, 2020). Under the Paris Agreement, Kazakhstan's Nationally Determined Contribution (NDC) was to reduce GHG emissions by 15% below the 1990 levels by 2030. Given the trends of emissions increasing in the last decade, the reduction of emissions 15% below the 1990 levels will require policies and measures for implementation of green technologies. Climate Action Tracker (Climate Action Tracker, 2020) rates Kazakhstan's NDC target as "insufficient," meaning that Kazakhstan's climate plans are not consistent with holding warming to below 2°C, as required under the Paris Agreement. Climate Action Tracker (2020) notes that Kazakhstan "fails to take steps towards achieving a Paris Agreement-compatible emissions pathway" due to its plans to expand coal and oil production.

The country's efforts in the field of clean energy were strengthened after EXPO 2017 ("Future Energy"), which was held in Kazakhstan. New renewable state programs were implemented and additional budgets were allocated for research related to creating a green economy, clean energy, and green technologies. The widespread adoption of green technologies enables Kazakhstan to embark on a new path, ensuring balanced and sustainable development of regional economies. With advancements in this field of knowledge, there have been positive phenomena, such as the emergence of additional jobs, an improvement in quality of life, and a reduction in risks to human health, as well as the preservation of non-renewable resources and the replenishment of renewable resources.

There is no actual single definition of the word "green" or environmentally friendly technology, as far as we know. As noted by (Winterton, 2016), "green chemistry" does not simply mean chemistry "in harmony with the environment"; and "green energy" is not only about "healthier and safer technologies and processes" (Kravanja et al., 2015). The general approach involves the implementation of their purpose – reducing the harmful "impact on the environment by reducing the amount of resources consumed, reducing the amount of waste" by promoting a circular economy and resource recovery program through deep processing, incorporating mechanisms and principles that work in nature in production processes, and improving energy efficiency of production (Sarbassov et al., 2013), improving the properties of materials from the standpoint of environmental safety. However, with the advent of the term "green economy," the definition of green technologies has acquired a new meaning – the use of green technologies should bring about not only an environmental impact, but also economic and social benefits.

The burgeoning literature on energy transitions has an interdisciplinary nature and addresses an important goal in regards to the reduction of carbon emissions (Geels et al., 2018; Odell et al., 2018; Vigoya et al., 2020). The energy transition towards low-carbon technologies is likely to have a significant impact on extractive industries (Bazilian, 2018). Nuclear energy, for example, is considered one mechanism to increase energy security and sustainability and to "reduce the use of fossil fuels" (McKie, 2020), but the safety and environmental issues of uranium mining should be carefully taken into account (Abdildin and Abbas, 2013). The research on the green, clean, and sustainable technologies, as well as measures of their impact on "the environment, society, and the economy" (Sikdar, 2020), were conducted in many developed countries, but not very much in Kazakhstan and Central Asia (Sabyrbekov and Ukueva, 2019). Gaining access to research cites is often difficult in Kazakhstan and the countries of Central Asia (Jonbekova, 2020).

In our search of literature related to green technologies in Kazakhstan, we found that (Ospanova, 2014) reported about the early progress of Kazakhstan in terms of a green economy, (Mukhtarova and Zhidebekkyzy, 2015) surveyed six experts on the development of "green technologies" in Kazakhstan, (Terehovics et al., 2017) analyzed the potentials of solar energy in Kazakhstan, (Karatayev and Clarke, 2016) reviewed the potentials of green energy, (Kerimray et al., 2016) analyzed different scenarios for mitigating climate change, (Kerimray et al., 2018) studied energy transition in the residential sector, (Kozhakhmetova et al., 2019) conducted a survey on the efficiency of green energy projects, and (Abdildin and Abbas, 2016) proposed a multiattribute utility theory for addressing economic, technological, environmental, and safety concerns in the energy problem.

This work presents the use of green technologies in Kazakhstan based on analysis conducted throughout 2019. The main questions guiding our study were 'What is the overall situation with green, clean, and sustainable technologies in Kazakhstan?', 'What proportion of industrial companies in Kazakhstan use green technologies?', 'Which regions of the country utilize green technologies and in which sectors of the economy?', 'What are the effects of using green technologies?', and 'What are the common barriers for developing green technologies in Kazakhstan?'.

The contribution of this paper is threefold. First, this is the first countrywide study on the use of green technologies in Kazakhstan. Our survey covers all 2,042 industrial organizations in Kazakhstan, from which we selected 266 reporting the use of green technologies. Second, it presents the current state of green technologies in the country. For the detailed analysis, we narrow the number of companies to 141 and present a comprehensive analysis of the industrial companies in Kazakhstan that utilize green technologies. Based on the reported cases, we rank all 17 administrative-territorial units of Kazakhstan by the absolute number of green technologies used, presenting examples and the effects of using green technologies in each region. We also discuss the barriers for and potentials of using green technologies by presenting the distribution of the 611 enterprises (by region) that do not currently use green technologies. Third, our work contributes to the literature on the topic of green technologies. Our results are novel in that there has not been any similar research conducted in Kazakhstan or the region of Central Asia regarding the use of green technologies. The remaining part of the paper is as follows: Section 2 briefly describes the methodology used in this work, Section 3 presents our results, Section 4 discusses common barriers, and Section 5 concludes the work.

2. METHODOLOGY

The International Center for Green Technologies and Investment Projects (https://igtipc.org/en/) was the first to analyze Kazakhstan's enterprises in a large-scale survey. The implementation of the special program provided information on the use of green technologies by enterprises in industry and on the main problems and barriers impeding introduction of promising green technologies.

As part of the collection of information for subsequent analysis, the Center developed a questionnaire for business entities utilizing green technologies in the Republic of Kazakhstan. This questionnaire is also aimed at obtaining information on the environmental, economic, and social effects of green technologies presented in Kazakhstan. A comparative analysis was performed based on data from questionnaires that were filled out by enterprises.

The questionnaire contained the following sections:
1. Information about the enterprise;
2. Information on green technologies used;
3. Environmental and economic effects:
    - Resource efficiency;
    - Reduction of greenhouse gas emissions;
    - Reduction of emissions and discharges of pollutants into the environment as a result of economic activity;
    - Reduction of emissions in the field of waste processing (municipal/industrial);
    - And others;
4. Social effects (job creation by gender).

The questionnaire process of surveying enterprises consisted of the following stages: interaction with the Office of Governors of regions and cities of republican significance. Within the framework of existing memoranda, the Center sent 17 letters to Governors of each administrative-territorial unit with a request to assist in the collection of data from enterprises on the use of green technologies. To intensify the collection of information, the Center sent official letters to enterprises, as well as organizing calls to enterprises. Additionally, trips to the enterprises were organized for employees from the Center.

The list of enterprises for analysis (2,554 enterprises in total) was provided by the Committee for Environmental Regulation and Control of the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan. During the collection of information, it was revealed that some enterprises had irrelevant or missing contact information (addresses and phone numbers). As a result of this, the Center sent a letter to the Committee on Statistics of the Republic of Kazakhstan requesting information on existing enterprises. According to the Committee, 226 enterprises were inactive. In addition, in the process of contacting and analysis, the Center identified 286 enterprises that were not in the category of enterprises issuing greenhouse gases.

As a result, the Center received 877 official letters from 2,042 enterprises (a 42.9% response rate), of which:

- 266 enterprises submitted questionnaires on the use of green technologies (380 cases) in various sectors of the economy; and
- 611 enterprises submitted official letters on the non-use of green technologies.

At most enterprises, the questionnaires were undertaken by the environmental engineers or the environmental units involved in preparing environmental protection plans, obtaining environmental permits, and preparing environmental reports. In some enterprises, the role of environmental responsibility is limited to the collection of information, and 'environmental decisions,' such as environmental reporting and the preparation of action plans that are coordinated by the environmental department of the parent companies. The filling out of questionnaires in large enterprises was carried out by process engineers or environmental managers, from the management departments of large holdings.

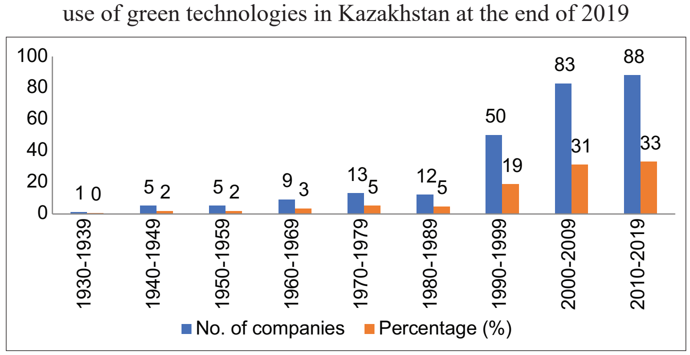
Thus, the analysis of the application of green technologies was carried out for 266 enterprises, but 141 enterprises were selected for calculating the target indicator, in which the data on the questionnaires were filled in completely.

3. RESULTS AND DISCUSSION

3.1. Listing the Enterprises by the Year of Foundation

Out of the 266 factories and enterprises that utilize green technologies, the majority (76.4%) were established after the independence of Kazakhstan (1991) (Figure 4). However, despite this, many enterprises require detailed modernization and implementation of environmentally friendly technologies. Many enterprises in the country apply both foreign and domestic technologies. In the Pavlodar region, Bogatyr Komir LLP (http://www.bogatyr.kz/en/), LLP Company Neftekhim LTD (https://nephtechim.kz/), and JSC "Station Ekibastuz GRES-2" (http://www.gres2.kz/index.php?view=3) reported the use of green technologies from Germany, France, and Kazakhstan (Polyset LLP). The use of green technologies brings new job positions, for example, 30 new jobs were created at the enterprises of Kazzinc LLP (https://www.kazzinc.com/en/), 162 jobs opened up at Ekibastuz GRES-1 LLP (https://gres1.kz/kz/), and 25 jobs were created at the Aktobe Ferroalloy Plant (https://www.kazchrome.com/en/business-overview/divisions/aktobe/) in 2019.

Figure 4: Year of foundation of the 266 companies that reported the use of green technologies in Kazakhstan at the end of 2019



3.2. The Use of Green Technologies by Sectors of the Economy and Territorial Units of Kazakhstan

Our analysis revealed the sectors of the economy in Kazakhstan where green technologies are used (Figure 5). We tried to classify the 380 reported cases by sectors of economy, where, for example, the 24 cases of dust collection in coal-fired power stations are placed in "Heat power engineering" and the percentage is calculated as 100*(24/380). Similarly, the 99 reported cases with renewable energy sources were separated from other sectors to clearly distinguish them from, for example, technologies used to improve energy efficiency. At first, it may look like that the major share of reported cases of green technologies is predominantly in 'green' industries (which use green technologies by definition, such as the waste management sector and RES), while major emitters of emissions – such as mining and metallurgy, as well as the oil and gas industries – reported less number of green technologies. However, such a separation gives a better understanding of the types of green technologies used. Besides that, we also wanted to see the distribution of green technologies (e.g., in waste management) by regions of the country, not only by sectors of the economy. Unlike other countries (Darko et al., 2017), green building technologies in Kazakhstan are not widespread, so there is a big potential for investors in Kazakhstan.

Figure 6 illustrates how the 380 cases of the use of green technologies are distributed among 14 regions of Kazakhstan and its three largest cities – Almaty, Nur-Sultan (capital), and Shymkent – which together represent all 17 administrative-territorial units of the country (map is adapted from ("Kazakhstan Provinces," 2020)). We found that the largest number of green technologies are used in the Karagandy, East Kazakhstan, Aktobe, and Atyrau regions, as large industrial enterprises of the country are concentrated in these regions. The total number of green technologies used in these areas is 209, or 55% of the total number (380). Note that we present this information in absolute numbers, not in relative numbers, i.e., not as a share of organizations using green technologies from total number of surveyed organizations by region. Such a ranking would not be accurate at this moment because there is no one-to-one relation between the 380 reported cases and the enterprises, as some companies presented several cases.

Figure 5: The distribution of the 380 reported cases of implemented green technologies in different sectors of economy

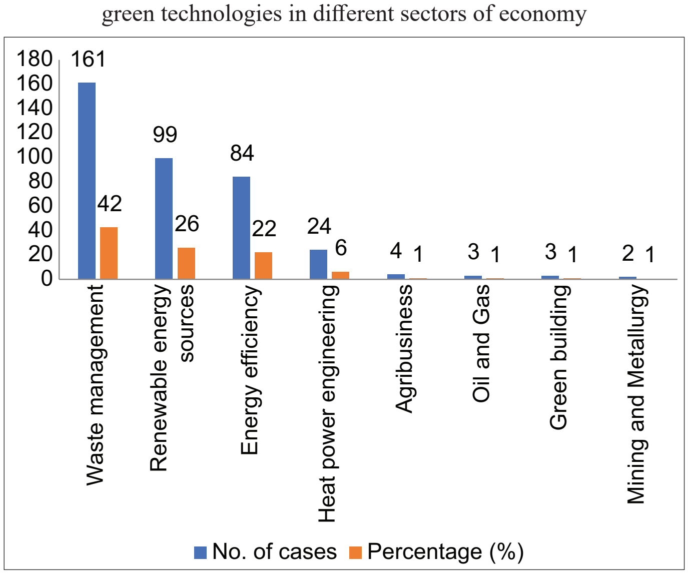


Figure 7 presents the distribution of the 380 reported cases in different sectors of the economy. The second echelon for the use of green technologies is in the following regions: Pavlodar, Kostanay, West Kazakhstan, and Zhambyl, as well as the city of Nur-Sultan. The total number of green technologies actually used in these areas is 97 out of 380, or 25.5% of the total number of applied green technologies in the regions of Kazakhstan. The smallest amounts of green technologies used are in the Almaty, Kyzylorda, Turkistan, Mangystau, North Kazakhstan, and Akmola regions, and the cities of Shymkent and Almaty. The total number of green technologies used in these territorial units is 74 out of 380 (or 19.5%).

3.3. The Effects of Using Green Technologies: Examples from Regions

We now present the examples of the effects of using green technologies in administrative-territorial units of Kazakhstan. The numbers presented below (e.g., tons of emission reduction) (i) imply the effect after the implementation of the green technologies compared to the situation before the implementation, and (ii) represent numbers received in the 2019 study from various organizations in the administrative-territorial units.

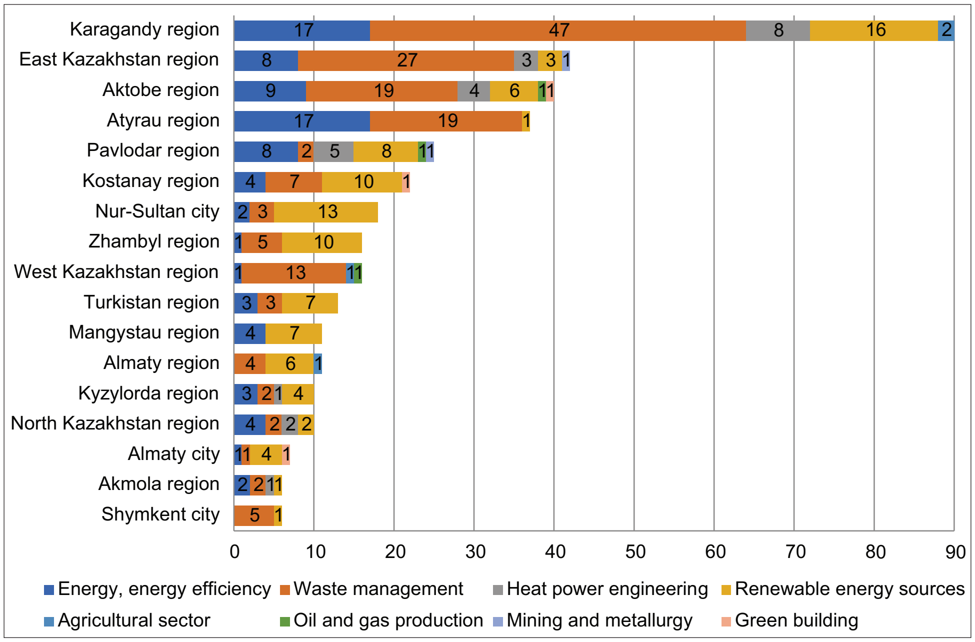
3.3.1. Karagandy region

The largest number of cases of green technology use, according to our survey, was identified in the Karagandy region – 90 cases. According to ArcelorMittal Temirtau JSC (2019), the use of technologies to reduce the concentration of dolomite dust led to a reduction in atmospheric emissions from 570 mg/m^3 to 50 mg/m^3, with the environmental effect of reducing dust emissions by more than 500 tons per year; the dust concentration was reduced from 500 mg/m^3 to 20 mg/m^3, since filters reduced dust emissions by 640 tons/year. There was also a decrease in particulate matter dust by more than 30% and lead by 87%, with dust collection improved by 95% and sulfur dioxide emissions into the atmosphere decreased by 70%.

Between 2014 and 2018, there was a decrease in air pollutants: SO_x by 19.76%, CO_x by 13.35%, and NO_x by 45.94%, as well

Figure 6: Distribution of the 380 reported cases of the use of green technologies in Kazakhstan

Figure 7: The 17 administrative-territorial units of Kazakhstan ranked by the use of green technologies in different sectors of the economy



as a decrease in pollutants of 99% for sulfuric acid and 100% for wastewater (ArcelorMittal Temirtau JSC, 2019). Inorganic dust emissions into the environment decreased by 10%, and emissions of SiO_2 decreased by 20-70% (Saryarka Komir Mining and Processing Company LLP, 2019).

3.3.2. East Kazakhstan region

In the East Kazakhstan region, there were 41 cases of green technology use reported. They contributed to the reduction in the emission of pollutants, mainly solid waste. According to Firma Etalon LLP (2019), the processing of solid waste amounted to 24,000 tons/year. The enterprises also reported the reduction of solids by more than 30%, lead by 87%, and sulfur dioxide emissions by 70% after the implementation of clean technologies (Kazzinc LLP, 2019).

3.3.3. Aktobe region

In the Aktobe region, 40 cases of green technology use were reported, 19 of them in the field of waste management, nine in the field of energy efficiency, four in dust collection, six in renewable energy, one in oil and gas production, and one in green building construction.

The technologies used by enterprises/issuers of greenhouse gases are aimed at reducing emissions of pollutants: dust by 80% (Mugalzhar Neftestroy LLP, 2019), inorganic dust by 70% (Technogran Aktobe LLP, 2019), and dust and gas emissions by 99% (Interstyle LLP, 2019), as well as a decrease in flue gases by 73.5 thousand m^3/h (Technogran Aktobe LLP, 2019) and a reduction in particle emissions into the environment of 13.5 tons/year (Aktobe branch of "Alties Petroleum International BV," 2019). There is a decrease in the disposal of waste (sludge tailings) in the amount of 250-400 thousand tons/year (Donskoy Ore Mining and Processing Plant, 2019). Filtration units have been installed in plants of this region, allowing 99% of the smallest dust particles to be captured (Alina Group LLP, 2019). In addition, chromium-containing materials are processed by processing mineral raw materials: chrome spinel powder (KhShP-01,02,03) on the wet enrichment line using hydroseparation, gravity enrichment, and chemical methods, with a capacity of up to six thousand tons/year (Sailan Aktobe LLP, 2019). In the enterprises of the region, there is a decrease in the consumption of industrial water due to the re-use of industrial water in production (Stroydetal LLP 2019).

3.3.4. Atyrau region

In the Atyrau region, the green technologies are aimed at reducing greenhouse gases, reducing the emission of pollutants, and improving resource efficiency. There is the use of technology for processing chicken waste of more than 11,200 tons of chicken waste a year (Promekologia LLP, 2019), as well as 50% energy savings (SBP KazMunayGas-Drilling LLP, 2019). The reduction of greenhouse gas emissions into the environment was: CO_2 - 15%, CH_4 - 2.5%, and N_2O - 3% (SBP KazMunayGas-Drilling LLP, 2019).

3.3.5. Pavlodar region

In the Pavlodar region, green technologies are mainly aimed at reducing greenhouse gases and ensuring the efficient use of resources. For example, according to the Pavlodar Aluminum Plant (2019), there has been a decrease in pollutant emissions of 2,376 tons/year, and technologies are used to reduce pollutant emissions into the environment to 10-15 times less than they were. They also report that particulate matter emissions are reduced from 25 mg/m^3 to 5 mg/m^3. At the same time, the degree of purification of the gas stream from dust corresponds to the level of 80-85% dust collector efficiency. Additionally, a decrease in the concentration of particulate matter in flue gases decreased five-fold from 1,600 mg/m^3 to 300 mg/m^3, and the efficiency of ash collection increased from 97% to 99.6% (Ekibastuz GRES-1 LLP https://gres1.kz/kz/). At the power plant of JSC Eurasian Energy Corporation (2019), ash increase in ash collection efficiency rose to 99.5%, sulfur dioxide capture up to 18% (dust removal). The disposal of industrial waste in the ash dump decreased approximately 30-100 thousand tons/year (Power plant of JSC Eurasian Energy Corporation, 2019).

3.3.6. Kostanay region

According to the State Communal Enterprise called Tobol, after the implementation of green technologies, the emissions of pollutants into the atmosphere were reduced by 57.5%. There is also a decrease in the discharge of pollutants into the environment from the economic activities of the Branch of JSC Aluminum of Kazakhstan KBRU; the degree of purification is, on average, from 28.6 to 99.63%. Also, there is a decrease in GHG emissions by 76.5%, a decrease in waste generation by 31%, reduction of emissions in the field of organic waste processing (manure in the amount of 44 tons/day and slaughterhouse waste in the amount of 1 ton/day), and reduction of pollutants into the environment from 96 tons/year to 1.6 tons/year (ILIN LLP, 2019).

3.3.7. Nur-Sultan city

The technologies are used to reduce emissions in the field of waste processing (municipal/industrial); in particular, used tires do not end up in a landfill in the amount of 1,800 tons per year, as reported by KazKauchuk LLP (2019), and there is also a decrease in specific emissions from coal ash from 1,500 to 350 mg/m^3 (Astana-Energy JSC, 2019). At the same time, energy savings of up to 10% have occurred to other tower-type installations (Astana Metiz Project LLP, 2019).

3.3.8. Zhambyl region

According to the Department of Main Gas Pipelines in the Taraz branch of JSC Intergas Central Asia, the technologies for water disinfection through direct electrolysis are used with a chloride content of at least 20 mg/l and a hardness of no more than 7 mEq/l at stations with a capacity of up to 5,000 m^3/day. According to Kazphosphate LLP (2019), the utilization of 'boiler' dust amounts to 21-22 thousand tons/year, and processed 'boiler' dust from accumulators, used as phosphorus-potassium fertilizers, is about 1-1.5 thousand tons/year. There is also a decrease in GHG emissions due to the introduction of the system of accounting of GHG emissions, which is about 18-21 thousand tons of carbon dioxide per annum, due to reducing the consumption of natural gas in the production of phosphorite agglomerate.

3.3.9. West Kazakhstan region

Green technologies in the region (e.g., the Kazakhstan branch of Karachaganak Petroleum Operating B.V., ICM Recycling, and Batys Power LLP) are aimed at reducing emissions of pollutants to 31,399 tons and the total reduction in CO_2 GHG emissions down to 950,591 tons. There is also a 60% reduction in the volume of liquid waste into the environment (Uralskaya poultry farm LLP, 2019) and a decrease in waste disposal (namely, sorted plastic, metal, waste paper, and other municipal solid waste) to 100%. Technologies, which used to significantly reduce the load on landfill, also help to reduce pollution of groundwater and atmospheric air with the products of decay of solid waste, as well as reducing emissions in the field of waste processing. There is also a decrease in GHG emissions by 10%, a decrease in emissions and discharges of pollutants into the environment by 10%, reduction of emissions in the field of waste processing by 100% through processing into fertilizers (Uralskaya poultry farm LLP, 2019).

3.3.10. Turkistan region

The technologies here are aimed mainly at reducing GHG emissions and improving resource efficiency. There is a decrease in environmental pollutants of 65,000 tons (Green Technology Industries LLP, 2019) and a reduction in greenhouse gas emissions of 1.99 tons/year (JV Inkai LLP, 2019), as well as a decrease in the amount of oily waste by 80,000 tons of product/raw material per year, down from 100,000 tons of waste (Kazecosolutions LLP, 2019).

3.3.11. Almaty region

A good example of the use of green technologies from this region is the reduction of greenhouse gases, which is estimated at 2,735 tons of CO_2 (MAEK-Kazatomprom LLP, 2019).

3.3.12. Mangystau region

Here, green technologies are used to reduce GHG emissions from desalination plants in the amount of up to 180 tons/year (LLP "MAEK-Kazatomprom," 2019).

3.3.13. Kyzylorda region

This region reported ten cases of the utilization of green technologies. After the implementation of green technologies, the efficiency of exhaust gas treatment at a 2-stage gas treatment plant reached 85%, and at the 2nd stage (wet cleaning), it reached 95%, with the overall cleaning efficiency reported as 99% (JSC PetroKazakhstan Kumkol Resources, 2019).

3.3.14. North Kazakhstan region

The North Kazakhstan region uses green technologies for energy efficiency, waste management, and dust collection. The examples include a decrease in the volume of harmful emissions into the atmosphere by 75% and plastic processing up to 4,000 tons (Raduga LLP). Technologies are also aimed at reducing pollutants from nitrogen oxides in flue gases (JSC SevkazEnergo, 2019).

3.3.15. Almaty city

The largest city of Kazakhstan, Almaty, reported only seven cases of green technology utilization. A good example of the reduction in the emission of pollutants into the atmosphere was reported by Hydro-Power LLP (2019) as follows: solid reduced by 71 tons/year and gaseous reduced by 119 tons/year.

3.3.16. Shymkent city

In the city of Shymkent, green technologies are utilized in waste management and in renewable energy. The examples include the production of organic fertilizer of up to 34,000 tons/year, which leads to the reduction of unpleasant odors from sludge wastes due to the treatment of sediments by anaerobic digestion in digesters, and 'clean' electricity generation at 3.5 million kWh/year.

3.3.17. Akmola region

According to Kazger-Kus LLP (2019), green technologies helped to reduce dust emissions by 99% and emissions of ammonia and hydrogen sulfide by 35%. Another example was presented by RSU-16 LLP (2019), where green technologies helped them achieve a 90% reduction in pollutants and GHG emissions.

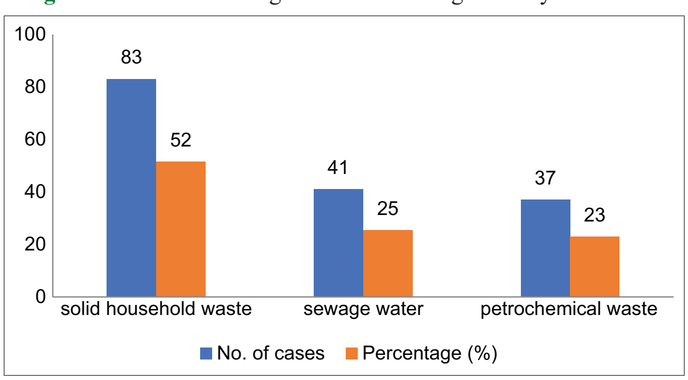
3.4. The Use of Green Technologies in Waste Management

The major use of green technologies in the regions of Kazakhstan is observed in the waste management sector, which accounts for 42.3% of the total number of clean technologies. Figure 8 illustrates the use of green technologies in waste management by sub-sectors. Recycling is an important component of sustainable resource use. This indicator is an important component of solid waste management. The current situation in the field o f waste management in Kazakhstan is characterized by the following problems the transportation, removal, and disposal of solid waste do not meet the standards; the legacy of historical waste; the growth of new industrial waste and household waste. To address these issues, it is necessary to rebuild an integrated waste management system.

3.5. Dynamics of the Energy Intensity of the Economy

One of the key indicators of the development of the country, as well as its energy sector, is the energy intensity of the economy. The energy intensity is the ratio of total energy use to the GDP measured in the tons of oil equivalent (toe) per 1000 US Dollars. Based on data from the International Energy Agency (IEA, Energy Intensity, 2019), we compare the energy intensity of Kazakhstan to the world and to the United Kingdom as an example of a country with excellent energy intensity (Figure 9). As we can see, between 2000 and 2017 Kazakhstan improved the energy intensity of the economy from 0.246 to 0.2 toe per 1,000 USD (a 23% improvement); however, in comparison with the world's and UK's statistics, there is great potential for improvement. This can be done, in part, through the use of green, clean, and sustainable technologies. Let us now discuss the barriers for developing these technologies.

Figure 8: Green technologies in waste management by sub-sectors



4. Common barriers for developing green technologies

Figure 10 represents the distribution of the 611 enterprises in Kazakhstan that reported not using green technologies. As we can see, Karagandy and East Kazakhstan regions are again among the "leaders," because they are the largest and most industrial regions. Certainly, we could compare the shares of enterprises which utilized green technologies to the total number of enterprises participating in the survey (877) and then rank the regions, but again, this may not be accurate, since not all (2,042) enterprises provided data and/or participated in our study. It is more important to understand the common barriers for developing green technologies.

Our analysis of enterprises by sectors and regions on the green technologies used revealed a low degree of awareness and interest of enterprises in the implementation of green technologies. This is because we generally observe:

- A weak degree of development of the market for green technologies;
- There is no methodology and terminology for green technologies, with no classification of green technologies;
- There is not enough statistical information (national and regional) on the implementation of green technologies;
- Weak incentive support measures for businesses using green technologies;
- Enterprises cannot calculate the economic component from the introduction of green technologies, in this regard, they do not feel the economic effect of their use;
- There are no qualified personnel in the field of green technologies, including ecologists, economists, engineers, and technologists;
- The market for the service and supply of green equipment is not sufficiently developed;
- There is no single platform for participants in the green technology market (investors, owners and developers, suppliers of technologies and equipment, business, public and private quasi-sectors of the economy, etc.).

The existing system of environmental regulation is weak:

- Technical emission standards for power and heat industries are several times too high for European standards for SO_2,

Figure 9: Energy intensity measured in terms of primary energy and GDP, 2000-2017

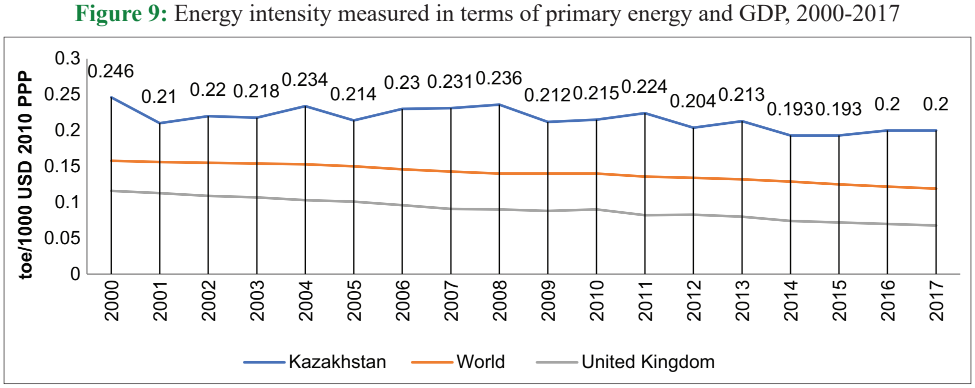
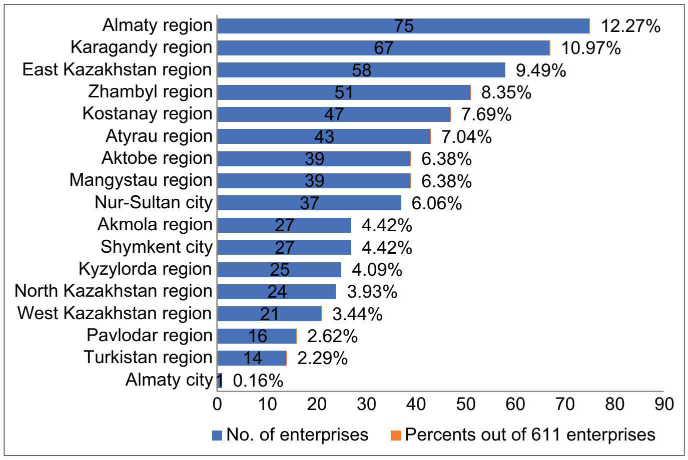


Figure 10: Distribution of 611 enterprises that reported not using green technologies



NOx, and PM (OECD: Addressing Industrial Air Pollution in Kazakhstan, 2019);

- In the permitting system, emission limit values for enterprises are determined based on compliance of concentration levels with environmental quality standards rather than emission limits that an industry could achieve when applying the best available techniques (BAT) (OECD: Addressing Industrial Air Pollution in Kazakhstan, 2019);
- Enterprises in Kazakhstan obtain emission limit values based on the highest level of emissions measured during the maximum production output. This allows enterprises to comply with the legislation without investing in processes, technologies, and techniques (OECD: Addressing Industrial Air Pollution in Kazakhstan, 2019).

Some of the above mentioned barriers (e.g., the lack of professionals) were also found in developing green buildings in Malaysia (Samari et al., 2013) and in Ghana (Chan et al., 2018), for example; and some other barriers were found in RES development in the Central Asian region (Kaliakparova et al., 2020). Kazakhstan is faced with many reasons that slow down the adoption of green technology strategies at the enterprise level and at the national policy level. Many Kazakhstani enterprises are branches of large industrial or communal holdings, or groups with headquarters in Nur-Sultan, Almaty, or abroad. In such large enterprises, decisions on significant investments in environmental management are made at the head offices, while the enterprises themselves do not have sufficient authority to make such decisions.

The market for green technologies in Kazakhstan is at an early stage. In general, compared to the international green technology market, Kazakhstan is rather lagging behind. Over time, domestic enterprises will begin to switch to green technologies and, in this case, Western experience will contribute to the rapid development of ‘green’ industries. So far, ‘green’ technologies come to our country through the transfer of foreign technologies, and not from their own developments.

In the process of collecting information, it was revealed that there is no common understanding of the term ‘green technologies’ in the country and no unified statistics on the technologies implemented. It was also revealed that at some enterprises, technologies are not fully accounted for, there is no description of technologies, no documentation is maintained, there are not always calculated indicators of resource and economic efficiency of the implemented technologies, there is no monitoring of the use of the introduced technologies, and there are no additional motivational measures for enterprises that stimulate the use of green technologies. The introduction and widespread use of green technologies in Kazakhstan requires coordinated actions on various fronts, including the regulatory framework, removing barriers and introducing institutional and economic incentives. Although Kazakhstan has environmental legislation and regulations, a comprehensive strategy needs to be developed, including several possible instruments for policy implementation.

5. CONCLUSIONS

In this work, we presented the results of the survey of all Kazakhstani companies that have a relation to green technologies. The idea was to analyze the state of the development of green technologies in Kazakhstan, identifying the sectors of the economy where green technologies are better developed and where there is a high potential for improvement. Out of the 380 reported cases presented by the enterprises, the majority were in the waste management sector (42%), renewable energy sector (26%), or energy efficiency (22%). The green building construction sector (1%) turned out to be the least developed sector of the economy. Kazakhstan is making some progress in developing its energy infrastructure, focusing on electrification and gas transmission infrastructure. The share of the population with access to electricity is almost 100%, however, a high share of electricity generation from coal (~70.25%) – mainly on high-ash coals of the Ekibastuz basin – and significant losses in electric networks (~20%) cause high levels of environmental impact from the electric power industry. Our results also show that more cases of using green technologies are found in the industrial regions of the country. The results also reveal that other regions of the country, located mainly in the south part of Kazakhstan, as well as the largest industrial regions (Karagandy and East Kazakhstan), have high potential for the use of green technologies. Analysis of data on the applied ‘green technologies’ by issuing enterprises in the regions showed that some enterprises have already implemented ‘green’ technologies, while some have partially implemented them. The technologies used differ greatly in the effectiveness of the impact of the enterprise on the environment. Each technology itself is multifactorial; for example, by purifying wastewater, we get the opportunity to obtain an additional secondary product – in the form of either fertilizer or biogas – for generating electricity or components of production residues that can be returned to the production cycle, while the purified water can also be reused in production or be used for other economic purposes; additionally, the effect of reducing air emissions is obtained. The net results are both environmental and economic benefits. The problems lie in assessing and calculating all the effects of the introduction of green technology. In general, we observe that Kazakhstan is progressing in the right direction, but a lot of work should be done in the near future to better contribute to the world's effort on achieving a green economy and more sustainable development.

6. ACKNOWLEDGEMENT

This work was supported in part by the governmental grant number "Бп044" provided to the International Center for Green Technologies and Investment Projects by the Ministry of Ecology, Geology, and Natural Resources of the Republic of Kazakhstan. Work of Aiymgul Kerimray was supported by the Postdoctoral Fellowship provided by Al-Farabi Kazakh National University.

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