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Women in Kazakhstan's Energy Industries: Implications for Energy Transition

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Abstract: Kazakhstan has a relatively high level of overall gender development, as well as of female employment in its energy industries. Diverse views and backgrounds are necessary to address the challenges of curbing emissions in Kazakhstan, a major fossil fuel producer and exporter. However, our analysis of the Labor Force Survey indicates that female representation among energy sector managers and overall workforce has been falling over time. Moreover, we find that women in Kazakhstan's coal mining, petroleum extraction, and power industries are concentrated in low-skilled and non-core occupations. Next, by analyzing data on labor compensation within energy occupations, we discover signs of persistent vertical discrimination, which may reduce incentives for women to upgrade their skills. Finally, we find that major shocks, such as the COVID-19 pandemic, may stall or reverse prior progress in increasing the energy sector's gender diversity. Our findings contribute to raising gender awareness among the stakeholders in Kazakhstan's energy sector in order to facilitate evidence-based gender mainstreaming.

Keywords: gender; diversity; discrimination; carbon neutrality; net-zero emissions; COVID-19

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1. Introduction

The ninth largest country by land area and with a population of 19 million, Kazakhstan is an upper middle income country located in the center of Eurasia. According to the 2019 Human Development Index (HDI), Kazakhstan is included in the Very High Human Development Group [1]. Furthermore, according to the Gender Development Index (GDI), Kazakhstan is in GDI Group 1 and is ahead of most countries in the region [2]. Specifically, Kazakhstan's women have higher expected years of schooling and higher life expectancy at birth than men. However, beginning in 2016 women's HDI has been falling behind that of men, mostly due to a widening income gap; in 2019, Gross National Income (GNI) per capita for Kazakhstan's women was only 57% of its value for men [1]. Furthermore, according to the Global Gender Gap Index (GGGI) [3], Kazakhstan's ranking on the political empowerment of women is very low, at only 106. Although Kazakhstan ranks as number 47–65 according to women's economic opportunities, health and survival, and education attainment, the overall GGGI ranking of Kazakhstan is only 80th out of 156 countries. In other words, women's income and representation have been lagging behind other aspects of gender development in Kazakhstan.

Kazakhstan is a major energy producer. It ranks in the top 15 countries worldwide based on total primary energy production, just behind Qatar and Norway [4]. It is the ninth largest producer and exporter of coal as well as the ninth largest exporter and 17th largest producer of crude oil. The petroleum industry accounts for 50% of total exports and 30% of government tax revenues [5]. Together with metal mining and coal mining, petroleum extraction produces 30% of Kazakhstan's GDP. Furthermore, Kazakhstan ranks in top 15 countries according to domestic coal consumption. Coal accounts for 70% of the country's electricity generation, followed by natural gas (20%) and hydropower (10%). Renewables (solar and wind power) account for less than 1% of the electricity generated in Kazakhstan.

Kazakhstan's specialization in fossil fuel exports, reliance on coal-based power generation, and the presence of energy-intensive mining and metallurgy industry has resulted in the country's large contribution to global greenhouse gas (GHG) emissions. In 2018, Kazakhstan ranked 14th in CO_2 emissions per capita and ninth in CO_2 emissions per unit of GDP [6]. Kazakhstan's Paris Agreement Nationally Determined Contribution includes decreasing GHG emissions by 15% of its 1990 level by 2030. In order to curb emissions growth, Kazakhstan introduced an emissions trading scheme (ETS) in 2013; however, the effectiveness of the ETS has been limited as emission levels and intensities continue to rise [6,7]. In 2020, Kazakhstan's government set a goal of achieving carbon neutrality by 2060. This would involve "abandonment of new coal-fired generation projects and phasing out of coal combustion (2021–2025); a programme to plant two billion trees (2025); the doubling of renewable energy sources in electricity generation (2030); 100 percent sorting of municipal solid waste (2040); sustainable agriculture across 75 percent of arable land (2045); 100 percent electrification of personal passenger transport (2045); the use of green hydrogen; and the complete phase-out of coal-fired production (2050)" [8] (p. 1). Achieving this ambitious goal is complicated by the prevalence of fossil-fuel subsidies, limited competition in Kazakhstan's energy sector, and technically outdated capital and infrastructure [6].

In light of Kazakhstan's status as a major fossil fuel producer, its scaling up of decarbonization efforts, and the challenges facing its development in the gender dimension, we examine the inclusiveness of Kazakhstan's forthcoming energy transition. Specifically, our study investigates the following:

1. To what extent have women benefited from employment opportunities within Kazakhstan's energy sector, which has been the driver of its economic growth?
2. Do female and male employee earnings in the energy sector differ?
3. What impact will Kazakhstan's transition to carbon neutrality likely have on women currently employed in its energy sector?

In general, the gender dimension of the energy transition is very complex and multifaceted [9]. It involves the effects of the phasing out of fossil fuels on women directly employed by the relevant industries, family members of employees of fossil fuel industries, and the impact on local communities due to changing economic and social fabric [10,11]. In addition, gendered effects concern changes in energy consumption, the growing importance of renewables, and demand for innovation [12,13]. Most of these complex interrelations are beyond the scope of our study, as we focus on analyzing the potential impacts of Kazakhstan's low-carbon transition on women directly employed by the energy sector. We analyze official statistics from 2010–21 and find that, although there was progress in terms of increasing overall gender diversity, Kazakhstan's energy industries continue to be male-dominated, with women accounting for a small and declining share of the sector's workforce and concentrated in low-paying occupations. This creates challenges for ensuring that the energy transition in Kazakhstan is just and inclusive.

In general, female work force participation in Kazakhstan is around 60%, which is the same level as the average of the OECD countries [14]. In 2016, the government of Kazakhstan adopted the Concept of the Family and Gender Policy to indicate its priorities for achieving gender equality, including measures to reduce gender violence and discrimination. One of the key developments was an initial reduction, followed by the full elimination, of the list of professions officially barred to women. The list, a legacy of Kazakhstan's history as part of the Soviet Union, included jobs with high levels of risk to health and safety, especially from the point of view of women's reproductive health [15]. However, a key concern remains. Women earn 67% of what men earn on average, as female employment is concentrated in low-paying sectors such as public health, education, and food services. Moreover, many women are self-employed or work in the informal sector, which means that their access to social security, including pensions, may be limited [14]. Furthermore, although Kazakhstan's women are well represented across all levels of education and most disciplines, they are under-represented in the engineering and technology fields. Female enrollment in vocational programs in oil and gas/chemical technologies and in geology/mining has generally been 20–25% and 15–25% of total student body, respectively. In university-level programs, women account for 30% of the student body. A worrying sign is that the latter two indicators have been decreasing during the last decade [16]. Coupled with low numbers of women in the engineering and technology fields is an overall low graduation level of students in these disciplines. Data from UNESCO [17] shows that in 2019, only 2%, 3%, and 20% of university students in Kazakhstan graduated in the science, information technology, and engineering disciplines, respectively. These data are consistent with 2012 and 2006 data [18,19]. General interest among young people in scientific careers is low in Kazakhstan because well-paying jobs in scientific and technical fields are limited and the prestige of being a scientist or engineer is low.

To a large degree, positive outcomes of gender development in Kazakhstan originate from the relative economic equality of men and women that existed during the socialist regime in Eastern Europe and the former Soviet Union [20]. The pressures of collectivization, industrialization, and World War II, combined with the later period of generous maternal leave and the widespread system of daycare services resulted in an 80% female labor force participation rate in the socialist countries [20]. In fact, in the 1980s, women accounted for 58% of engineers in the Soviet Union [21]. However, the transition to a market economy brought about unemployment, rising income inequality, deteriorating quality of institutions, and a revival of patriarchal values, reversing many of the advances of gender development in the region [22].

Women's empowerment in Eastern Europe and Soviet Union happened in parallel with female emancipation in the West. During the second half of the 20th century, post-World War II rising wages, improvement in household technologies, and the spread of birth-control methods allowed greater numbers of women in industrialized countries to enter the workforce. Moreover, the long-term decline in manufacturing and the rising role of services as well as the increasing use of computers created many jobs for women. Growing female labor force participation was accompanied by the convergence of women's and men's wages. This resulted in the female/male earnings ratio in the US increasing from 60% in the 1960–1970s to 80% by 2010 [23]. Human capital factors such as educational attainment and full-time work experience explain most of this reduction in the gender pay gap [24]. Additional factors such as race, region, occupation, and industry explain most of the remainder of the gap.

Furthermore, traditional gender roles and stereotypes continue to influence the difference in earnings between women and men. Specifically, women are more likely than men to bear the "parental penalty". This "motherhood penalty" stems from the perceived lower competence and commitment of female employees with children [25]. This penalty results in lower starting salaries and less firm-specific training offered to women of childbearing age. In addition, mandated parental and child-care leaves raise employers' costs when hiring women and increases incentives to discriminate based on gender [26]. Furthermore, women's psychological attributes such as aversion to risk, competition, and bargaining result in reduced earnings and representation in high-level jobs [27–29].

The economic theory of discrimination developed by Becker [30] explains the gender pay gap in light of the discriminatory tastes of employers. Employers compensate their disutility when hiring women by a gender wage discount. If employers operate in a product market that is competitive, then firms hiring more women have a cost advantage. In the long run, such firms would displace firms with lower shares of women [31]. However, uncertainty regarding work interruptions by hired women and imperfect information regarding their expected productivity may lead to lower pay, training, and promotion for women [32]. Higher job search costs faced by women due to discriminatory practices increase firms' monopsony power over women [33]. Furthermore, a firm's position in the wage distribution hierarchy determines the employer's ability to exercise discrimination and results in a higher concentration of women in firms that pay lower wages to both genders [34].

Unlike many industries where female representation has grown with time, the energy sector remains dominated by male employees. "Despite making up 48% of the global labour force, women only account for 22% of the labour force in the oil and gas sector and 32% in renewables" [35]. Furthermore, the share of energy companies participating in gender diversity initiatives is among the lowest of all industries. This may be linked to the low representation of women within the decision-making bodies of energy companies. The percentage of senior female officials and managers in the EU oil and gas sector is 10%, compared to 33% across all sectors [35]. Yet, multi-country research shows that companies led by women demonstrate superior corporate and social performance [36]. A survey of female entrepreneurs in Kazakhstan indicated that the female approach to management is holistic: "female leaders in entrepreneurial firms in the Kazakhstani context believe that a key contribution of leaders is the creation of value, well-being and benefit for a wide range of stakeholders including employees, communities and the organisation itself. Women's effective interaction with the influences from the uncertain and changing environment also ensures the firm's success. Furthermore, women entrepreneurial leaders perceive the creation of results that are beneficial to all stakeholders and the wider community as an important dimension and demand of their leadership role. They emphasize the importance of both financial and non-financial returns, as well as sustainable outcomes of their entrepreneurial activities" [37] (p. 165). Studies demonstrate that limited gender diversity severely constrains the energy sector's ability to meet multiple challenges faced by the industry, especially those related to climate change [38–40].

The reviewed literature suggests that the gender dimensions of energy transition are complex and calls for further research. These dimensions are influenced by the current state of energy systems and energy policies, on the one hand, and the progress of gender development, on the other hand. There is a growing number of studies on this topic, focused on Europe, North America, South America, and Africa. Such studies on Kazakhstan are few, and include Gender Assessment [41], focusing on district heating in Kazakhstan, and the Role of Women in Energy [42], analyzing Kazakhstan's energy firms without sub-sector disaggregation. Here, we complement these previous studies and the general body of literature on gender in energy by carrying out an in-depth analysis of the involvement and earnings of women in Kazakhstan's energy industry by sub-sector and occupation type. This allows us to identify barriers faced by women when entering or advancing within the energy industry.

2. Materials and Methods

We conducted exploratory statistical analyses of employment and labor compensation data reported by the Ministry of Economy of Kazakhstan. The data for our analysis of employment were from the Kazakhstan Labor Force Survey (KLFS). In 2010 and 2014, the KLFS collected approximately 200,000 observations from individuals 15 years of age and older on a quarterly basis. In 2017, the KLFS changed their sampling methodology such that it collected approximately 500,000 observations from individuals 15 years and older on a monthly basis. We used the International Labour Organisation's International Standard Classification of Occupations ISCO-08 for 2010 and 2014 and Kazakhstan's National Classifier of Occupations (NCO) for 2018 and 2020 to identify occupations. The NCO is harmonized with ISCO-08. Furthermore, the definitions of economic sectors used in this paper are based on the second version of the Statistical Classification of Economic Activities in the European Community (NACE rev. 2). We created a subsample of each dataset that includes only the first observation of each individual in order to ensure that observations were independent. In addition, we restricted our subsample to include working individuals between the ages of 25 and 60. The age adjustment was performed in order to ensure that the included individuals had completed their schooling. Finally, we focused on the primary job, and thus only responses related to the primary source of employment are included.

We used data reported for 2010, 2014, 2018 (the year prior to the COVID-19 pandemic), and 2020 (the year of the pandemic) and focused on employment in coal mining, petroleum extraction, and power and heat generation, transmission, and distribution (hereinafter referred to as the power industry). We placed each observation into one of eight groups of occupations: *managers*, *engineers and surveyors*, *science/IT professionals*, *technicians*, *semi-skilled workers*, *equipment operators*, *unskilled laborers*, *and others* (see Appendix A for the composition of these groups of occupations).

We obtained data for our analysis of earnings from the published annual average monthly nominal salaries of employees. Kazakhstan's Ministry of Economy prepares this publication based on the annual reported salary structure and distribution submitted by all enterprises. Data are reported as monthly salaries for full-time employees by occupation type: average salary of men, average salary of women, and average salary across all employees within a given occupation. Following Blau and Kahn [24], we used the salary data to determine the gender pay gap as follows:

$$\textit{Pay gap} = 100\% \times \textit{average women's salary} / \textit{average men's salary} \quad (1)$$

We interpret a higher value of this ratio as evidence of equal pay for the same set of skills, conditional on men and women having the same work experience. This is an acceptable assumption, as [41] finds that women have the same work experience as men in Kazakhstan's district heating sector. For this reason, a pay gap value of 100% can be interpreted as a sign of absence of horizontal discrimination based on gender.

In order to analyze how compensation varies across occupations for men and women, we evaluated the following relationship:

$$\log(\textit{average women's salary}_i) = \textit{constant} + \textit{beta} \times \log(\textit{average men's salary}_i) + \textit{error}_i \quad (2)$$

Here, the subscript *i* refers to a specific occupation, while *beta* measures the percent change in women's salaries associated with a percent change in men's salaries. In other words, the coefficient *beta* measures the elasticity of women's salaries with respect to men's salaries. Assuming similar work experience for men and women, if the estimated value of *beta* is equal to unity there is no sign of vertical discrimination in earnings on the basis of gender. Based on our obtained results, we intend to estimate two hypotheses. The first null hypothesis states that the estimated beta is equal to or greater than one. Rejecting this null hypothesis indicates the presence of vertical gender discrimination. The second null hypothesis states that the estimated beta of the current period is no less than the estimated beta of the previous period. Rejecting this null hypothesis provides evidence that vertical discrimination has decreased over time. A *p*-value of less than 0.05 allows us to reject each respective null hypothesis at a 5% level of significance.

We estimated Equations (1) and (2) separately for coal mining, petroleum extraction, and the power industry. Our initial intention was to analyze salary data using the same years as for employment data from the KLFS. However, firm survey data on salaries by occupation were very sparse for the years 2018–2020. As a result, we analyzed labor compensation data for 2010, 2014, 2017 (the pre-pandemic year), and 2021 (the year of the pandemic).

3. Results

3.1. Overview of Kazakhstan's Energy Industries

Coal mining is one of Kazakhstan's oldest industries. It supplies a key input to the domestic power industry, as 70% of electricity and combined heat and power plants use coal as fuel. A distinct feature of Kazakhstan's coal market is its importance for residential consumption; 30% of all households and 70% of rural households rely on coal for space heating needs [43]. In the 2010s, coal mining exhibited stable production (See Figure 1) concentrated in the eastern and northern regions of Kazakhstan. Though the industry is not a large employer on a national scale (See Figure 2), in coal-mining regions it is often the only large employer. Moreover, salaries in coal mining are competitive, higher than salaries in the power industry (see Figure 3).

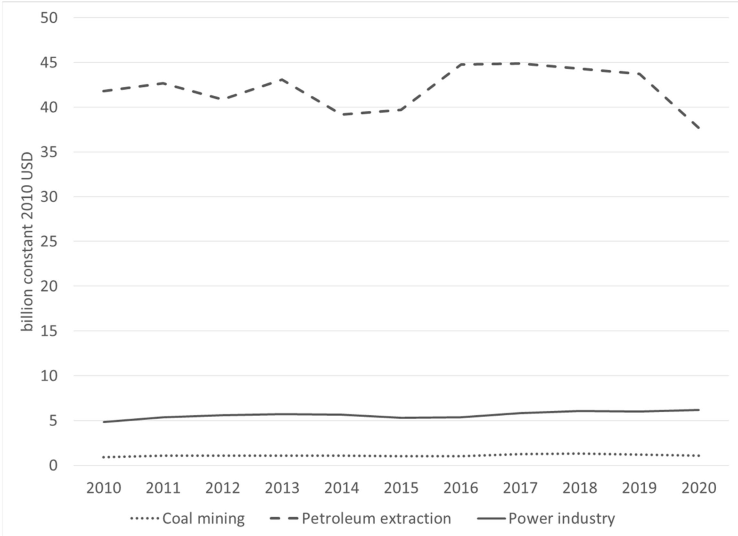

Figure 1. Energy sector output value. Source: Ministry of Economy of Kazakhstan "Industry of Kazakhstan", various years.

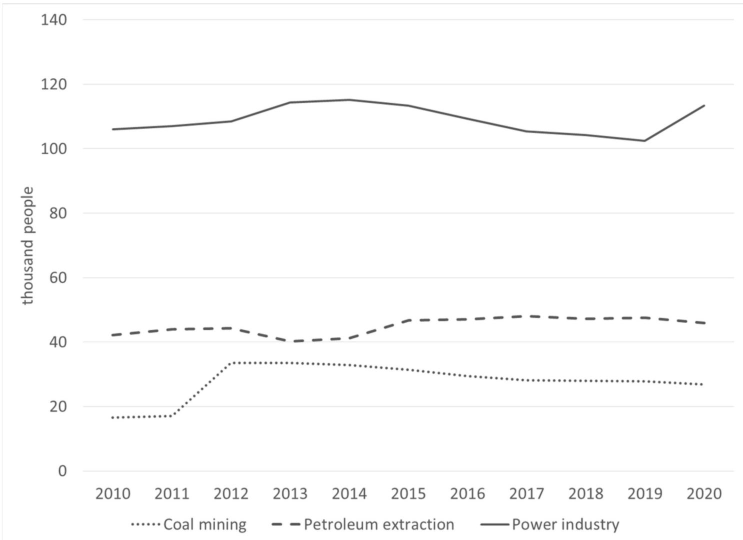

Figure 2. Energy sector employment. Source: Ministry of Economy of Kazakhstan "Industry of Kazakhstan", various years.

Kazakhstan's petroleum industry can be traced back to the early 1900s. However, it experienced considerable growth only after Kazakhstan became independent in 1991. Petroleum extraction is by far the largest among Kazakhstan's energy industries in terms of its value of output (see Figure 1). Approximately 75% of petroleum production is exported, and its output value fluctuates in step with international oil prices. The number of jobs in the sector has been relatively stable, and represents around twice the number of jobs as in the coal industry (see Figure 2); these jobs are concentrated in the western region of Kazakhstan, the location of most oil and gas production. A key feature of this industry is very high and increasing salary levels compared to most other sectors in Kazakhstan's economy. During 2010–2020, petroleum sector salaries were respectively 3 and 4–4.5 times greater than in coal mining and the power industry (see Figure 3).

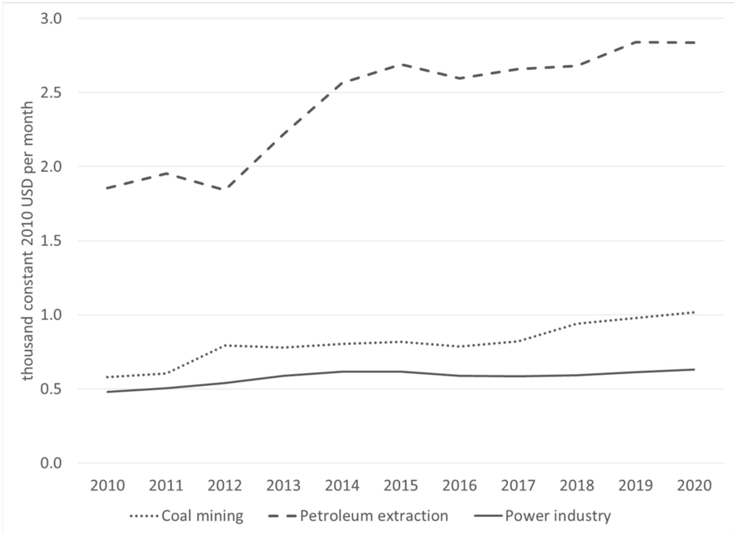

Figure 3. Energy sector salaries. Source: Ministry of Economy of Kazakhstan "Industry of Kazakhstan", various years.

The power industry includes electricity and heat generation, transmission, and distribution. The country's largest coal-based electricity generation plants are in the eastern and northern regions, close to the coal mining centers [44]. Kazakhstan's industry (primarily mining and metallurgy companies) consumes approximately 60% of the total electricity produced [45]. Households account for 20% of total consumption; however, this share is considerably higher in the country's south, where Kazakhstan's large urban centers are located. Lately, cryptocurrency mining accounts for an estimated 8% of total electricity produced, which results in Kazakhstan ranking in the top three cryptocurrency mining jurisdictions after only China and the USA [45]. Years of underinvestment in power sector facilities and infrastructure have resulted in frequent brownouts and a high level of losses, which represent 14% of the total value of the power industry's output [45,46]. As follows from Figures 1–3, the power industry is the largest employer among Kazakhstan's energy industries, employing 1.6–1.8 times as many people as are employed by petroleum extraction and coal mining combined. However, salaries in the power sector are lower than in coal mining, and substantially lower than in petroleum extraction.

3.2. Analysis of Employment by Groups of Occupations

The KLFS data allow us to analyze employment in the energy sub-sectors by occupation and gender. Average 2010–2020 values indicate that *semi-skilled workers* and *equipment operators* were the most common jobs in coal mining and petroleum extraction (see Table 1). In the power industry, *semi-skilled workers* and *other workers* accounted for the greatest share of the total workforce. In addition, we note a much smaller share of high-skilled staff in the case of Kazakhstan; in the US, engineers account for 10% of the petroleum workforce, [47] versus only 4% in Kazakhstan.

As we proceed to analyze women's engagement in this sector, we find that Kazakhstan's women held 30% of the jobs in the power industry, 22% of the jobs in coal mining, and 18% of the jobs in petroleum extraction (see Table 2). In comparison, in the EU women accounted for 22%, 12%, and 10% of jobs in the same industries, respectively [35,48]. Kazakhstan's women have low representation in the most in-demand jobs, namely, *equipment operators* and *semi-skilled workers*, especially in coal mining and petroleum extraction. In contrast, women accounted for over 60% of *other workers* (i.e., functional jobs not directly involved in operations, such as those related to office and administration) in all three sectors. Furthermore, women accounted for 32% of *unskilled laborers* in petroleum extraction and over half of *unskilled laborers* in coal mining and the power industry. Importantly, women accounted for 20–30% of jobs as *engineers and surveyors* and *science/IT professionals* in all three sectors.

Table 1. Distribution of total workforce across groups of occupations, average, 2010–2020.

Occupation	Coal	Petroleum	Power
Managers	7%	5%	6%
Engineers, Surveyors	2%	4%	6%
Science/IT professionals	1%	2%	1%
Technicians	4%	8%	11%
Semi-skilled workers	26%	21%	30%
Equipment operators	40%	37%	15%
Unskilled laborers	9%	11%	12%
Other	10%	13%	19%
Total	100%	100%	100%

Source: Ministry of Economy of Kazakhstan "Labor Force Survey", various years.

Table 2. Share of women in the total workforce by occupation, average, 2010–2020.

Occupation	Coal	Petroleum	Power
Managers	16%	14%	16%
Engineers, Surveyors	26%	22%	30%
Science/IT professionals	33%	31%	38%
Technicians	12%	17%	19%
Semi-skilled workers	14%	10%	15%
Equipment operators	15%	6%	19%
Unskilled laborers	56%	32%	53%
Other	63%	60%	64%
Total	22%	18%	30%

Source: Ministry of Economy of Kazakhstan "Labor Force Survey", various years.

Next, we investigate how women's representation has changed over time. We see steady growth at 3–7% per year in female-held jobs in *unskilled laborers* in all sectors, and high growth at 13–15% in *science/IT professionals* in petroleum extraction and the power industry (see Table 3). At the same time, women's share among *managers* declined in coal mining and the power industry as well as among *engineers and surveyors* in petroleum extraction and the power industry. The share of women across all occupations remained unchanged in the power industry, while it declined at 1% per year in coal mining and 4% per year in petroleum extraction. It is possible that the low representation of women in Kazakhstan's energy sector was, to some degree, the outcome of government regulations and the list of professions officially barred to women until 2021. However, the falling shares of women in certain occupations are not likely to be related to these regulations, as the number of occupations included in this list declined over time.

Table 3. Average annual growth rate in share of women in occupations, 2010–2020.

Occupation	Coal	Petroleum	Power
Managers	−5%	−5%	9%
Engineers, Surveyors	5%	−2%	−3%
Science/IT professionals	Na	14%	13%

Table 3. *Cont.*

Occupation	Coal	Petroleum	Power
Technicians	Na	1%	3%
Semi-skilled workers	9%	−12%	−6%
Equipment operators	6%	−6%	−1%
Unskilled laborers	7%	6%	7%
Other	1%	4%	3%
Total	−1%	−4%	0%

Source: Ministry of Economy of Kazakhstan "Labor Force Survey", various years.

3.3. Analysis of Earnings by Occupation

Turning to our analysis of earnings, we first examine the distributions of men's and women's salaries across all occupations by sub-sector in 2017, the pre-pandemic year. We find that in the case of the power industry, the distributions of men's and women's salaries are essentially the same. For both coal mining and petroleum extraction, women's and men' salaries are similar in the lower range; however, in the upper range for men there are no corresponding observations for women. This reinforces our conclusions from Section 3.2 that women are under-represented in well-paying occupations within the energy sector.

Second, we analyze how the earnings of women and men diverge when grouped by occupation. For this purpose, we first consider the descriptive statistics of the gender pay gap during 2010–2021 (see Table 4). We find that the pay gap was the lowest in petroleum extraction, where on average women earned 99% of the salaries of men employed in the same occupation. In the other two sectors, women earned 91–92% of men's salaries for the same occupations. In all three sectors, there was a decrease in the difference between average salaries paid to women and men employed in the same occupations. However, the range of values of this gap has increased over time.

Table 4. Descriptive statistics of gender pay gap within occupations.

	2010	2014	2017	2021	Average 2010–2021
COAL MINING					
Mean (%)	79.36	91.73	88.43	109.55	92.27
Standard deviation (%)	26.18	23.91	23.37	60.76	33.56
Min (%)	43.10	37.30	49.20	46.50	44.03
Max (%)	163.90	141.60	136.70	231.70	168.48
No. occupations held by both women and men and women's salaries reported	29	32	30	11	
% occupations held by women	62	67	63	37	
PETROLEUM EXTRACTION					
Mean (%)	99.67	90.88	91.79	112.42	98.69
Standard deviation (%)	35.31	26.39	25.16	43.54	32.60
Min (%)	45.30	48.60	28.30	36.80	39.75
Max (%)	223.10	170.30	146.10	190.40	182.48

Table 4. *Cont.*

	2010	2014	2017	2021	Average 2010–2021
No. occupations held by both women and men and women's salaries reported	34	30	31	29	
% occupations held by women	71	67	66	35	
POWER INDUSTRY					
Mean (%)	85.23	87.77	92.47	98.49	90.99
Standard deviation (%)	15.89	18.57	29.50	32.52	24.12
Min (%)	53.20	42.60	34.20	33.80	40.95
Max (%)	114.50	129.50	219.80	226.40	172.55
No. occupations held by both women and men and women's salaries reported	33	33	32	153	
% occupations held by women	100	100	100	40	

Source: Ministry of Economy of Kazakhstan "Average salaries by sector and occupation", various years.

Third, we examine how salaries change as a person moves to a higher-paid occupation; specifically, do women's salaries increase at the same rate as men's salaries? In order to answer this question, we analyze the link between changes in men's and women's salaries using linear regression (2) (see Table 5). We observe that in the case of petroleum extraction women's and men's salaries are closely related; in 2014 and 2017 the rate of change in *women's salaries* between occupations was the same as or greater than the rate of change of *men's salaries*. However, in coal mining and the power industry, female salaries changed at a lower rate than male salaries and the link between the two (as measured by the estimated coefficient of *average men's salary*) weakened over time. In general, the explanatory power of the regression models (as captured by the adjusted R^2) was high in the case of petroleum extraction. In the other two cases, the explanatory power of the models was lower, which may be related to smaller sample sizes. Furthermore, several important factors, such as regional variations in earnings, are not taken in to account in our model due to lack of data availability. This consideration may be more important for the power industry, which is located in all regions of the country, than for coal mining and petroleum extraction, the operations of which are confined to specific regions. Our linear regression R-squared values, which are acceptable for cross-section models [49,50], indicate that our results are reliable. In fact, Wooldridge [51] indicates that smaller values of R-squared are not problematic in cross-sectional models as long as the standard errors of the coefficient estimates are small.

Table 5. Regression results: determinants of women's salaries.

Sector	Year	Coefficient Estimate	Standard Error	Constant	Adjusted R^2	Num. Obs.	p-Value [1]	p-Value [2]
coal mining	2010	0.8682 ***	0.1949	1.1979	0.4023	29	0.2523	
	2014	0.6789 ***	0.1258	3.6135 ***	0.4757	32	0.0080	0.0714
	2017	0.7043 ***	0.1278	3.3615 ***	0.5033	30	0.0141	0.4219

Table 5. *Cont.*

Sector	Year	Coefficient Estimate	Standard Error	Constant	Adjusted R^2	Num. Obs.	p-Value [1]	p-Value [2]
petroleum extraction	2010	0.7516 ***	0.1262	2.9855 **	0.5111	34	0.0289	
	2014	0.9725 ***	0.0985	0.2156	0.7687	30	0.3911	
	2017	1.1619 ***	0.1238	−2.2496	0.7438	31	0.1006	
	2021	0.7311 ***	0.0977	3.6571 ***	0.6626	29	0.0052	0.0001
power industry	2010	0.9370 ***	0.1000	0.5233	0.7305	33	0.2667	
	2014	0.7565 ***	0.1360	2.6570 *	0.4834	33	0.0416	0.0971
	2017	0.6898 ***	0.1223	3.5161 ***	0.4982	32	0.0083	0.2948
	2021	0.6915 ***	0.0569	3.6567 ***	0.4909	153	0.0000	0.5000

Source: Authors' calculations. Notes: ***: Estimated coefficient is statistically significant at 1%. **: Estimated coefficient is statistically significant at 5%. *: Estimated coefficient is statistically significant at 10%. [1] Testing the null hypothesis: coefficient ≥ 1. [2] Testing the null hypothesis: coefficient (current year) ≥ coefficient (previous year).

Finally, we note that gender outcomes in the energy sector were different before and during the COVID-19 pandemic. More specifically, before the pandemic, women worked in 62–71% of occupations in coal mining and petroleum extraction and 100% of occupations in the power industry (See Table 4). However, in 2021 women's representation in these occupations fell to 35–40% in all three sectors. This result may be related to the care functions that women provide for family members. During most of 2020–2021, Kazakhstan's public schools operated in an online mode and daycare services had very limited availability. This might have prevented many women from continuing work. As follows from Section 3.2 above, most women in the energy industries worked in low-skill jobs that were difficult to transform to remote work mode. Furthermore, as follows from Table 4, in 2014 and 2017 the petroleum industry exhibited no signs of vertical gender discrimination in earnings. However, in this sector the elasticity of women's wages compared to men's salaries decreased from 1.16 in 2017 to 0.73 in 2021. This indicates that the pandemic resulted in the reversal of prior achievements in reducing gender discrimination.

4. Discussion

What are the implications of our findings for Kazakhstan's transition to a low-carbon future? The plans to phasing out coal-based electricity and heat generation implies the closure of coal-mining companies. As a result, we can expect a disproportionately large impact on women from the phasing-out of coal mining, as our analysis of the impact of the COVID-19 pandemic on women in the energy sector demonstrates that crises tend to reverse gains in reducing gender discrimination. Furthermore, as female employees of coal mining companies are concentrated in unskilled labor, this group of workers may have greater difficulty adjusting due to an absence of transferable skills. The low and declining representation of women in managerial positions in coal mining further complicates the process of discussing ways to minimize the impact mine closure on women. It is necessary for coal mining stakeholders to begin such discussions, which might involve initiatives for re-training and skill upgrading for female coal miners. Studies of jobs for energy transition indicate that both high- and mid-level skills are required [52]. Furthermore, "examples from the UK and USA show that former coal miners, especially those with technical training, can easily be employed in wind energy projects" [47] (p. 14).

Our employment data analysis indicates that the power industry has the highest presence of women in its workforce of all the energy sub-sectors, as well as an increasing share of female managers. Moreover, women account for 15–38% of the semi-skilled and skilled labor force in the power industry. However, a worrying sign is that due to vertical gender pay discrimination, women in the power industry may have fewer incentives to upgrade their skills. This might hinder female involvement in innovation in the power industry, which requires diverse skills sets, approaches, and backgrounds [12]. Furthermore, the plans of Kazakhstan's government for transport electrification require addressing the presence of aging capital and infrastructure, large losses, and frequent brownouts [46]. This creates an additional demand for creative approaches to addressing current challenges in Kazakhstan's power industry.

Finally, due to Kazakhstan's natural resource endowments, its petroleum industry is likely to continue to play a key role in generating export and government revenues. Although gender discrimination in earnings is less of an issue in this sub-sector, the falling share of the female workforce as well as the low and decreasing representation of women among managers may constrain the petroleum industry in meeting its sustainability challenges (such as reducing its energy intensity). In addition, development of green hydrogen technologies in Kazakhstan is directly linked to its petroleum industry. However, limited access to women's talent in developing this green energy source within the petroleum industry represents another challenge for meeting Kazakhstan's goals of energy transition.

5. Conclusions

Our results shed light on the question of why women's income and representation have been lagging indicators in gender development in Kazakhstan. We find that women are concentrated in low-paying occupations in the energy industry, accounting for 30% of unskilled labor and 60% of the office and administrative workforce. Of the three energy sub-sectors, female representation is the highest in the power industry, where women account for 30% of total workforce. However, jobs in this industry are not highly paid. The petroleum extraction industry, which has been leading the country's exports and government tax revenues, has created few opportunities for women's engagement and empowerment among its employees. This most prosperous and highest-paying energy sub-sector employs few women, who account for only 18% of its workforce. Furthermore, we find that women hold only 14–16% of managerial positions in the energy sector, and except in the power industry, their representation has been falling over time. In comparison, the goal of large international energy companies is to achieve 30% female representation among senior managers [33]. On the positive side, average female salaries in all three industries have reached or exceeded men's salaries for the same occupations. In addition, in the pre-pandemic period the petroleum industry achieved relatively equal pay for both genders both within and across occupations. However, there are signs of vertical gender discrimination in labor compensation in coal mining and the power industry, which reduces incentives for skill upgrading by women.

In order to ensure that Kazakhstan's transition to a low-carbon future is just and inclusive, policy makers should adopt gender mainstreaming, promote STEM education among girls and women, and actively engage with stakeholders. Learning from the relevant international experience in this field is of paramount importance; e.g., [53]. Energy-sector leaders should embrace the idea of diversity as beneficial for their companies' bottom line, as diverse teams promote innovation and profitability [54]. Moreover, extractive companies that support diversity have better safety, environmental, and local community records [55]. Failure to attract, retain, and promote a female talent pool threatens the competitive position of Kazakhstan's energy sector as all industries increasingly compete for employees with skills relevant for automation, digitization, and artificial intelligence. In order to increase inclusiveness, energy companies should set specific diversity targets, implement flexible career options, and reconsider criteria for promotion. Furthermore, energy sector businesses should support female role models, develop mentoring, and promote a positive image of the industry among potential employees.

Our study is one of very few studies that rely on quantitative analysis of disaggregated data on gender in the energy sector. Our results may be considered as a baseline assessment that enables Kazakhstan's policy-makers and business leaders to formulate specific targets for increasing gender diversity in the energy industry. Moreover, our findings identify areas of special attention, including reducing pay gaps and vertical discrimination, promoting more women to managerial roles, and upgrading the skills of the entire workforce. Our research complements previous studies by providing a more detailed and up-to-date analysis of the topic. Further research remains necessary to learn from the personal experiences of women in Kazakhstan's energy industries in order to identify and remove barriers for gender diversity, which is a key requirement of a successful and inclusive energy transition.

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Appendix A. Groups of Occupations Used in Analysis of Employment

<u>**2010 and 2014**</u>

Managers: Administrative and Commercial Managers, Production and Specialized Services Managers.

Engineers: Engineering Professionals; Electrotechnology Engineers; Architects, Planners, Surveyors and Designers.

Science/IT Professionals: Physical and Earth Science Professionals; Mathematicians, Actuaries and Statisticians; Life Science Professionals; Information and Communications Technology Professionals.

Technicians: Science and Engineering Associate Professionals; Information and Communications Technicians

Semi-skilled Workers: Protective Services Workers; Building and Related Trades Workers (excluding Electricians); Metal, Machinery and Related Trades Workers; Handicraft and Printing Workers; Electrical and Electronics Trades Workers; Food Processing, Woodworking, Garment and Other Craft and Related Trades Workers.

Equipment Operators: Plant and machine operators and assemblers; Mining, Manufacturing and Construction Supervisors.

Unskilled Laborers: Elementary occupations.

Others: Business and Administration Professionals; Legal, Social, Cultural and Related Associate Professionals; General and keyboard clerks, customer services clerks; Personal services workers; Personal care workers.

<u>**2018 and 2020**</u>

Managers: Managers (primary and functional) in the corporate sector; Managers (managers) of specialized units in the corporate sector in the sphere of production and specialized service services.

Engineers: Technical professionals except electrical engineers; Electrical engineers; Architects, designers, surveyors and designers.

Science/IT Professionals: Physicists, chemists and related professionals; Mathematics, actuaries and statistics professionals; Life science professionals; Specialists-professionals in the field of management of air and sea transport; Information technology (IT) professionals.

Technicians: Technicians in science and technology; Information and communication technology technicians.

Semi-skilled Workers: Employees of services carrying out protection of citizens and property; Builder-assemblers, builder-finishers, painters and related workers, except electricians; Metalworking, equipment maintenance and related workers except electricians; Artifacts working with precision (precision) instruments, polygraphy and cartography; Electric, electronics and telecommunication workers.

Equipment Operators: Equipment operators, assembly and drivers.

Unskilled Laborers: Unskilled workers.

Others: Finance professionals; administration professionals; public relations, sales and marketing professionals; General and keyboard clerks, customer services clerks; Personal services workers.

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