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# Assessing initial conditions and ETS outcomes in a fossil-fuel dependent economy

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ABSTRACT

We analyze the energy market and ETS outcomes in Kazakhstan, a major fossil-fuel exporter. The energy market was characterized by the presence of large state-owned enterprises, prevalence of fossil fuel subsidies, and dominance of coal-fired generation. Despite the ETS, Kazakhstan's CO2 emissions and CO2 emissions intensity of its power sector continued to grow. Power sector investment and prices declined while CO2 emissions intensity of GDP reversed its downward trend. To increase ETS effectiveness it is necessary to prioritize stakeholder engagement, address deficiencies in carbon allowance allocation and trading, and enhance the carbon cost pass-through mechanism. Finally, formulating and implementing a comprehensive low-carbon transition strategy should improve ETS outcomes.

## 1. Introduction

An emission trading scheme (ETS) is a market-based climate policy based on a cap-and-trade mechanism whereby a cap is placed on total emissions from regulated carbon-intensive firms, which have to obtain an emissions allowance for each ton of the greenhouse gas (GHG) emitted. These allowances may be traded between ETS participants which, in theory, should create incentives for least-cost abatement. The long-run goal of an ETS is to encourage investment and innovation in low-carbon technologies. However, initial conditions and country specifics play a key role in determining the effectiveness of an ETS in achieving climate policy goals [1–3]. Kazakhstan was the first country in Asia and the first resource-rich middle-income country to launch a nation-wide ETS for carbon dioxide (CO2) in 2013. Kazakhstan may soon be followed by other resource-rich emerging economies as ETS initiatives are under consideration in Brazil, Chile, Colombia, Indonesia, and Mexico [4]. Our goal is to formulate lessons learnt from Kazakhstan's experience with introducing an ETS. To this end, we discuss initial conditions, how the Kazakhstan ETS (KazETS) was established, and evaluate its performance.

In general, effective low-carbon transition requires a three-pillar strategy [5]: (1) policies related to energy efficiency through standards and public engagement; (2) policies related to carbon pricing such as carbon taxes and ETSs; and (3) policies related to government supported low-carbon technology and infrastructure (refer to Box 1 for a more detailed discussion of the three pillars). Kazakhstan's government has unsatisfactorily used standards policies and public outreach initiatives to promote technological development and raise public awareness of climate change mitigation responsibility (See Box 2). Furthermore, Kazakhstan presently has no strategy for the energy sector which could direct low-carbon technology and infrastructure development. As a result, the government's programs supporting low-carbon technology and infrastructure are disparate individual instruments (See Box 3).

As a result, we focus our investigation on the KazETS as it has been the main policy instrument of promoting low-carbon transformation in Kazakhstan. We acknowledge that ETSs have inherent characteristics that may lead to less than optimal outcomes: implementing an ETS is a complex political and time-intensive task and is "beset by difficulties of complexity, uncertainty and delay" [6]; p.265); incumbent enterprises will lobby and often are allocated generous allowances which leads to over-allocation of allowances; and there may be adverse interactions between an ETS and other concurrent energy and climate policies. Nevertheless, ETSs are able to provide a stabilizing effect on economic activity and investment in fossil-fuel dependent countries: during periods of low energy prices emissions are low and so are carbon prices and vice versa during periods of high energy prices. This stabilizing effect is important because in net-oil exporting countries, such as Kazakhstan, evidence indicates that they experience higher business-cycle volatility

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relative to net-oil importing emerging and developing economies [7]. Furthermore, evidence from Malaysia reveals that in net-oil exporting countries, the majority of industries benefit from an oil price rise and suffer from an oil price fall [8]. Furthermore, evidence suggests that ETSs offer a means of introducing controls over emissions but also of avoiding major opposition from entrenched incumbents and have positive effects on the amount of green innovation [9,10].

However, our general finding is that the KazETS is yet to demonstrate its effectiveness: CO2 emissions intensity of the power sector and the GDP continued to increase while energy prices and investment declined. We explain this limited outcome of the KazETS by a number of reasons (1) changing external economic environment and dwindling export revenues shifted the government's focus from climate policy to economic recovery and redistributive policies; (2) pre-existing distortions from fossil-fuel subsidies and dominance of state-owned enterprises limited carbon cost pass-through and volume of emissions trading; (3) pushback from dominant firms made it difficult for the government to stay the course and resulted in a temporary suspension of the ETS. In addition to a number of technical shortcomings in ETS implementation, our findings highlight the need for adequate preparation and consensus building, reducing the state's presence in the economy and pro-competition policy implementation before launching such schemes. According to Nee and Opper [11] reduced state presence is a necessary condition to promote competitive markets in ex-socialist countries, such as Kazakhstan, as state ownership often leads to non-profit maximization strategies as well as a means for private enrichment of politicians.

This paper is organized as follows: the next section discusses key features of a fossil-fuel dependent economy. Section 3 discusses how Kazakhstan's ETS was introduced and sustained. Section 4 introduces a framework for analyzing ETS impacts. Section 5 evaluates the outcomes of the KazETS. Section 6 discusses our findings and provides policy recommendations.

## 2. What are the features of a fossil-fuel dependent economy?

Kazakhstan is one of the fossil fuel-dependent economies [12], i.e. "countries whose economies are highly dependent on income generated from the production, processing and export, and/or on consumption of fossil fuels and associated energy-intensive products" [13]; p. 10). A former centrally planned economy which was a part of the Soviet Union until 1991, it is the largest upper-middle income economy in Central Asia (per capita GDP in 2020 was $US 9056) with a population of about 19 million [14]. The country has abundant fossil fuel and mineral resources. Kazakhstan is the largest producer of uranium accounting for 42% of global uranium supply in 2019 [120]. In 2018, it was the world's 9th largest exporter of coal and 9th largest exporter of crude oil [15]. Its economy is highly dependent on petroleum exports – in 2017–18 the petroleum sector accounted for 49–56% of exports and 30–35% of state revenue [16]. Overall, the *extractive sector* accounts for around 30% of Kazakhstan's GDP [121].

Another key characteristic of Kazakhstan's economy is the dominance of its *state sector*, in the form of public services and state-owned enterprises (SOEs), which reflects its heritage of central planning. The state's participation in the economy as a proportion of total employment were 38% and 20% for the public sector and SOEs, respectively in 2016 [32]. Between 2016 and 2019 Kazakhstan's SOEs, led by Samruk-Kazyna, controlled productive assets that were valued at 53% of GDP [33]. The state holds 75% of Kazatomprom, the world's largest uranium producer, and 100% of KazMunaiGas, which accounts for 30% of the country's petroleum production and 80% of domestic refinery and pipeline capacity. A large percentage of both electricity and heat producers are either SOEs or joint stock companies (JSCs) with large government ownership. In 2016, 46% of total electricity produced in Kazakhstan was generated by Samruk Energy SOE and Kazatomprom, while JSCs with state ownership generated 31% of total electricity produced [34]. For district heating, 29% of enterprises are SOEs and 9% are JSCs which are partially owned by the government [35]. Dominance of large SOEs raises concerns about their efficiency and limits competition in Kazakhstan's economy.

Apart from the heavy reliance on its extractive sector and a significant presence of the state in the economy, Kazakhstan's production has been historically dependent on *coal-based electricity and heating* [36]. In 2018, coal accounted for 45% of its total primary energy supply and 70% of power generation [15]. Coal-based power and heat plants are technologically outdated as most were inherited from the Soviet Union. According to one estimate, turbine equipment depreciation in the country's thermal power plants is over 70% [27]. A significant amount of the coal-fired electricity is used by energy-intensive mining and metallurgical industries, which account for 12% and 26% of total electricity consumption, respectively [27,34]. These percentages are likely to grow: in 2018 the government discontinued collection of excess profits tax from firms operating in the mining industry [37] as part of the

**Box 1**
Three-Pillar Policy Approach to Low-Carbon Transition

The policy framework presented in the Stern Review on the Economics of Climate Change [17] for effective CO2 abatement suggests the use of three policy elements: removal of barriers to behavior change, carbon pricing, and technology policy [18]. Grubb et al. [5] extended this approach and identified three 'domains of change' – satisfice, optimize and transform – and corresponding 'pillars of policy' for tackling GHG emissions. Pillar 1 draws on behavioral economics and recognizes that non-price factors affect consumers' decisions. The dominant policy solutions for Pillar 1 are enforcement of public efficiency standards and citizen engagement. Pillar 2 relies on neoclassical economics and optimization theory. The principal policy solution is to raise the price of carbon, through carbon taxes or an ETS, so as to impose costs on polluters and provide price incentives for low-carbon energy. The third pillar draws on evolutionary economics, complexity theory and political economy to understand the transformation of whole economies, which are seen to be shaped by the interplay of technology, infrastructure, and institutions. Policies are designed to promote low-carbon growth through transformative investment coupled with strategic public planning and infrastructure investment.

Single-pillar policies have limitations due to the presence of synergies between pillar-specific policies. For example Mercure et al. [19] show that a combination of carbon pricing, feed-in tariffs and technology subsidies have the ability to greatly outperform single policy instruments and outperform the sum of the impacts of its components taken separately. Grubb et al. [5] show that the EU's decarbonization strategy is based around the three pillars.

Assessing Kazakhstan's low-carbon transition requires the evaluation of the effectiveness of the country's policies in each pillar of low-carbon transformation. The discussion of Kazakhstan's Pillar 2 policy, its ETS, is the main focus of this article. In Box 2 and Box 3, we provide a brief discussion of selected Pillar 1 and Pillar 3 policies pursued in Kazakhstan, respectively.

**Box 2**
Kazakhstan's Low-Carbon Transition Strategy – Standards and Public Engagement

Many of the environmental performance and energy efficiency standards for new facilities are less stringent in Kazakhstan compared to Russia, China and the EU. For example, $NO_X$ requirements for new power plants in Kazakhstan (320–550 mg/$m^3$) are at least double of those in the EU (150 mg/$m^3$) and more than four times the level allowed in China (50 mg/$m^3$) [20,21]. Furthermore, the standards are low for existing plants, double of the allowable levels for new plants [21]. Such low standards for old plants do not encourage modernization in the power industry. Similarly, low energy efficiency standards are present in residential and commercial buildings sector. For example, in Kazakhstan minimum R-values for windows are 37.5% lower than those of the Czech Republic [22]. Furthermore, for residential buildings constructed prior to 2013, district heating tariffs are not tied to actual consumption but are based on norms expressed in unit cost per square meter of living space. In addition, heat subsidies in Kazakhstan are significant - without subsidies the cost of heat in the capital city, Nur-Sultan, could increase by 500% [23].

In 2019 the average residential electricity tariff in Kazakhstan was 3.0 $US cents per kWh compared to 11.2 $US cents in Bulgaria and 34.6 $US cents in Germany [24]. The average residential natural gas tariff in Kazakhstan was 1.29 $US per gigajoule while it ranged from 10.75 $US per gigajoule in Hungary to 36.80 $US per gigajoule in Sweden [25]. However, a poll completed in Kazakhstan by the UNDP [117] indicated that almost two-thirds of respondents do not support an increase in heat and electricity tariffs. These facts suggest that Kazakhstan's public is poorly informed of the trade-off between the energy affordability due to fossil fuel subsidies, on the one hand, and climate change and the long-term economic prosperity of the domestic economy, on the other hand. The poor record of public engagement on the necessity of residential energy price reform is in line with the general limited nature and minimal effectiveness of Kazakhstan's government engagement with the private sector, NGOs, and the public [21]. Furthermore, public engagement in energy efficiency policy formulation remains in its infancy worldwide [5]. Yet, public engagement can effectively empower consumers by developing a feeling of responsibility for the consequences of their consumption of energy [26].

state's diversification strategy away from petroleum dependence.[1] Furthermore, Kazakhstan's Strategy 2050 and its Industrial Development Plan 2020–2025 identify metallurgy and mining as priority areas [110].

In addition to the abundant crude oil and coal reserves, Kazakhstan has sizable reserves of associated and non-associated *natural gas*. They were estimated at 1 trillion cubic meters in 2018 and at current extraction rates would last 40 years [38]. Natural gas is increasingly used in power generation as its share grew from 10% of generated power during 1990–2010 to 20% in 2015–18. However, distortions created by the government's 60% subsidy on domestic natural gas resulted in its low market price and has led most producers of associated natural gas to use it for re-injection to increase oil recoveries. In 2018, approximately 13 billion cubic meters of natural gas (28% of gross production) were reinjected into oil reservoirs to raise oil output rates. This volume is expected to increase in the 2020s as a result of Kazakhstan's policy of maximizing oil output [39].

Just like natural gas, other energy prices in Kazakhstan are heavily subsidized and significantly below cost-recovery levels [40,41]. The motivation behind the consumer subsidies is to ensure international competitiveness of the country's industries as well as to provide cheap residential energy, which is considered a basic "human right" [42,43]. During 2015-17 Kazakhstan's *fossil-fuel subsidy* was estimated at 16–20% of GDP with the bulk of support provided to the coal industry [44]. Such energy subsidies are pervasive in fossil fuel-rich middle-income countries [45]- where affordability of energy is perceived as a compensation for resource depletion and a social contract for containing political unrest [46].

As a result of its reliance on energy intensive resource industries, inefficient power generation, and subsidized energy prices, Kazakhstan is one of the most *emissions-intensive* economies in the world, even relative to countries which are heavily dependent on their extractive sectors [47]. In the 1990s (See Fig. 1), a large decline in output due to the collapse of the Soviet Union resulted in an initial reduction in Kazakhstan's GHG emissions which was more than offset during the 2000s by growing hydrocarbons production and lack of reform in the power sector [34]. In 2018, Kazakhstan emitted a total of 309 million tons of CO2 (MtCO2), which accounted for 80% of its total GHG emissions, of these 106.8 MtCO2 were generated by electricity and heat production [48]. Kazakhstan ranked the 21st largest CO2 emitter in 2018 [49]. In relative terms, Kazakhstan's emissions are even higher given its small population and GDP: in 2018 it ranked as the 14th largest by per capita emissions and 9th largest by CO2 per unit of GDP [49].

According to the *Paris Agreement*, Kazakhstan is committed to unconditionally decrease its GHG emissions by 15% by 2030 compared to its 1990 level. However, economic development goals of Kazakhstan's Strategy 2050 conflict with the country's CO2 reduction commitments: the Strategy anticipates annual economic growth of 3.7% between 2020 and 2025 [16] and electricity demand growth of 2.8% between 2015 and 2045 [50]. A major portion of the increase in electricity demand is expected to be supplied using the country's abundant coal reserves and, as a result, emissions are likely to increase- putting the Government of Kazakhstan's Paris Agreement pledge into question. As of 2018, Kazakhstan's emissions (320 MtCO2) have increased by 14% compared to those in 1990 (280 MtCO2). In comparison, in 2018 the EU GHG emissions decreased by 23% from their level in 1990.

## 3. Launching and sustaining the KazETS

The KazETS may be traced back to 2007 when the Kazakhstan government established the legislative foundations for an ETS: the Environmental Code set a requirement for specified power plants, oil-and-gas operators, mining companies, and manufacturing firms to prepare and report annual inventories for GHG emissions starting in 2008 [51]. In December 2011, the President of Kazakhstan signed a law introducing an additional chapter to the Environmental Code, which has been regulating the KazETS since January 2013. At that time the government envisioned that internationalization of allowances and offsets would become a source of funding to modernize the vintage capital present in many sectors of the economy. Specifically, the Environmental Code allowed implementation of technology transfer and investment in Kazakhstan under the Clean Development Mechanism (CDM) and Joint Implementation (JI) mechanisms of the Kyoto Protocol. In addition, consideration was given to linking the KazETS with the EU-ETS and South Korea's ETS, as the three systems had similar market designs [116]. The KazETS only covers CO2; however, the levels of nitrous oxide (N2O), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) are

[1] Excess profits tax for the petroleum industry ranges from 0 to 60%. Mining firms still pay a minerals extraction tax at rates which range from 0% to 18.5% depending on the type of mineral [120].

monitored. Methane emissions are currently excluded from the KazETS (in 2018 methane contributed 14.6% of Kazakhstan's total GHGs [52]). The sectors regulated by the KazETS include power and heat generation, oil and gas, mining, metallurgy, chemical and construction materials. As described in Section 2, many firms from these industries are SOEs or JSCs with significant public ownership, which created an inherent conflict of interest for the state. Phase 1, a one-year pilot, was implemented in January 2013 and covered 77% of total CO2 emissions by regulating 178 facilities [28]. However, faced with industry's opposition to the ETS (described below), the government curbed its ambitions as Phase 2, which ran from January 2014 until December 2015, covered only 50% of total CO2 emissions and regulated only 166 facilities [27]. In general, there was very little turn-over in facilities between phases - the reduction in regulated facilities between phases was concentrated in the chemical and construction materials sectors. During Phase 2, allowances were to be traded among KazETS participants at Caspy, the Caspian Commodity Exchange. Penalty rates for exceeding each ton of CO2 amounted to $US 51.7 per tonne in 2014 and $US 44.7 per tonne in 2015 [53]. A crucial feature of KazETS was prohibiting the pass-on of CO2 allowance costs or the costs of abatement to consumers' energy prices. Furthermore, power companies were not allowed to reduce energy production due to consideration of energy security [54].

In general, many of the *features of KazETS design were similar to the ones of EU-ETS* [31]. We refer readers to Sammut et al. [116] for an in-depth comparison of the designs of the KazETS and the EU-ETS as well as a discussion of expected of outcomes from the KazETS due to the differences in design and implementation. Key differences between the KazETS and EU-ETS were the former's short phase durations and prohibition of energy price increases due to CO2 allowance cost which, according to the policy transmission mechanism described below, would significantly limit KazETS effectiveness [55].

The implementation of the KazETS met strong industry opposition as the plan proposed to limit the amount of free carbon allowances in 2013 to below actual 2010 carbon emission levels [28]. Consolidation of regulated firms against the KazETS was intensified by the deteriorating macroeconomic conditions in 2014–15. During 2013–16, following a greater than 50% *collapse in the international oil price* Kazakhstan's value of fuel exports, which usually represents 70% of merchandise exports, plummeted, declining at 20% per year. As a result, Kazakhstan's real GDP growth rate slowed down from an average of 8% per year during 2000–13 to 4% in 2014 and just over 1% in 2015 and 2016. To reduce mounting pressure on the exchange rate and international reserves of its central bank, the Government of Kazakhstan undertook two major currency devaluations during KazETS Phase 2: a 19% devaluation in February 2014 and a 26% devaluation in August 2015. Both devaluations increased inflationary pressure as well as financial burden on many private and public companies with foreign-currency loans. The effects of the first devaluation gave impetus for industry associations (Kazenergy Association and Atameken National Chamber of Commerce) to lobby for relief from the burden of the KazETS. Specifically, the Kazenergy Association, comprising 80 major producers in the oil-and-gas and power industries, lobbied the Government of Kazakhstan to release energy sector firms from the KazETS on the grounds of loss of competitiveness, KazETS's weak legal foundation, and high monitoring, reporting and verification (MRV) costs [28].

It is important to note that the August 2015 devaluation changed the priority of the government towards economic recovery: the government became hesitant to allow any utility price increases or economic slowdown because of CO2 costs. Energy efficiency investment became a less pressing issue as the government looked for a stimulus package that would generate jobs. The Nurly Zhol $US 9 billion transport infrastructure expansion program was designed and implemented during 2015–19 and represented a key component of the stimulus package [56]. In fact, earlier carbon reduction objectives contradicted policies designed to mitigate economic decline and promote new industrial projects. Competition between proponents of different strategies in different ministries led to *conflicting priorities* of government programs [28]. Two examples of conflicting programs were the 2014 objective of stimulating investment in low-carbon technologies declared in the Concept of Development of the Energy Complex [54] and the 2009–2015 electricity price cap regulation. Between 2013 and 2015, this price cap regulation required mandatory reinvestments of all profits of power plants and prohibited payment of dividends from power assets. If an investment agreement with the Ministry of Energy was absent, a power plant had to sell power at the cost of production. This price cap regulation led to increased regulatory risks for private investments in power infrastructure and reduced incentives for energy efficiency projects [34].

In February 2015, the Government of Kazakhstan agreed with the industry associations' proposal to postpone the beginning of KazETS Phase 3 from 2016 to 2018. KazETS Phase 3 (2018–2020) covered 50% of total CO2 emissions by regulating 225 installations [57]. During the 21-month long *suspension period*, the Government of Kazakhstan amended the allocation method; the MRV system; trading procedures; and the operating rules [58]. First, in addition to the grandfathering method of allocating allowances (used during Phases 1 and 2) benchmarking was introduced in Phase 3. The grandfathering was based on annual average 2013–2015 emissions [59]. The benchmarking system consisted of 52

**Box 3**
Kazakhstan's Low-Carbon Transition Strategy – Low carbon Technology and Infrastructure

The penetration of renewable energy sources (RES) in Kazakhstan is limited as solar, wind and biomass electricity generation made up only 1.13% of the energy mix in 2019 [122]. The existing model of RES support faces many challenges. First, coal-fired power plants are obliged to buy renewable energy according to their share in total electricity generation. Currently, the share of renewable energy in coal-fired power plants costs is about 2–4.5% but could reach 15–30% by 2021 [27]. This policy increases the dependence of new renewable energy projects on the financial performance of coal-fired generation and the approval of electricity and capacity tariffs. Second, increased renewable generation may lead to electricity tariff growth and requires reconsideration of the government's objectives to maintain the competitiveness of the country's energy-intensive industry and energy affordability for households. Third, increased RES penetration faces three power grid-specific barriers: Kazakhstan's centralized electricity system does not allow quick or flexible reactions to changing electricity production and consumption profiles; there is lack of balancing capacity because of natural gas shortages caused by the government's 60% subsidy on domestic natural gas; and regional grids are incapable of integrating renewable energy without considerable investment [28–30].

Another element of low carbon technology promotion is Kazakhstan's plan to form a vertically integrated nuclear industry, including nuclear power plants. However, the low level of social support for the construction of nuclear power plants [31] and the existing low level of electricity prices question social and economic justification for the project. Moreover, the limited flexible generation capacity, and development of such large scale base-load nuclear power generation with an increased portfolio of renewable energy sources may create serious technological challenges for stability of the national power grid.

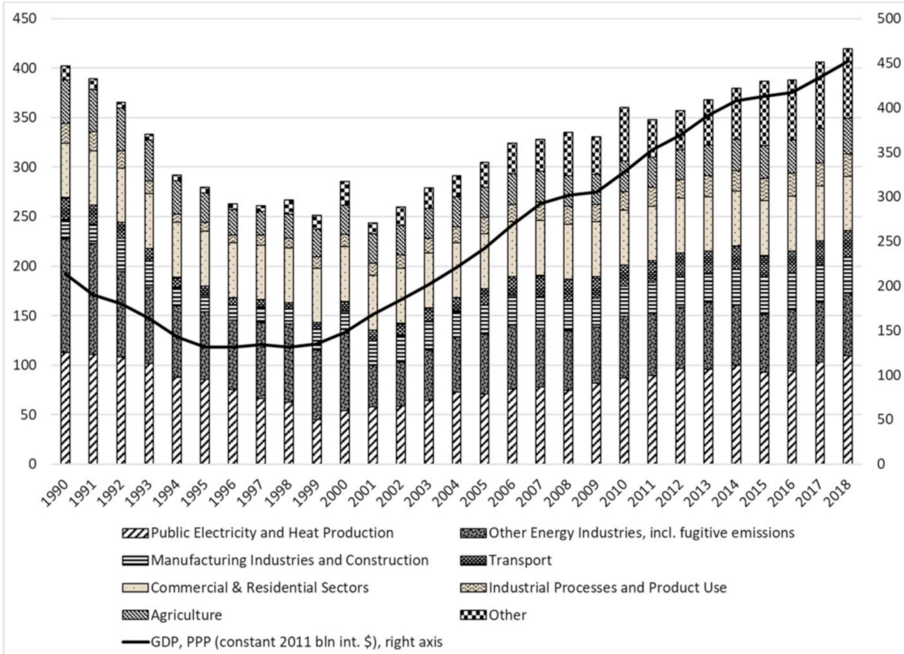


**Fig. 1.** Kazakhstan's GDP ($US bln) and GHG emissions (MtCO2eq).
Source: [123].

benchmarks for different product outputs and input fuel types [60]. For electricity and heat-producing plants, the facilities followed a fuel-dependent benchmarking principle in which plants using the same fuel were grouped together. Data indicate that of the 94 regulated electricity- and heat-generating facilities, 57 chose benchmarking and 37 chose grandfathering and that 83% of the regulated emissions were allocated under the benchmarking alternative [124]. One possible reason for the high percentage of facilities choosing benchmarking may be the result of Kazakhstan's relatively lax benchmarks (0.985 tCO2/MWh for electricity generated by coal and 0.621 tCO2/MWh for electricity generated by natural gas) compared with benchmarks in other jurisdictions, specifically Germany (0.75 tCO2/MWh for electricity generated by coal and 0.365 tCO2/MWh for electricity generated by natural gas) and Alberta (0.37 tCO2/MWh for electricity generated by coal and natural gas) [60–62]. The second major regulatory change was the implementation of an electronic MRV reporting system and transferring of the accreditation of MRV bodies to the National Center for Accreditation, which enables MRV bodies to be accredited according to ISO standards. However, the UNFCCC [52] reports that no changes in the rules for monitoring the completeness, transparency and reliability of data were reported in the 4th Biennial Report, which covered Phase 3. The third major regulatory change implemented in Phase 3 was the ability of individual firms to conduct over-the-counter transactions, which enabled large industrial groups to net carbon positions within their groups. The over-the-counter trading did not change the number of allowances traded as a share of total allocated allowances (i.e., 1.4% in Phase 3 versus 1.3% in Phase 2) [63]. To sum, the three major changes made to the KazETS at the beginning of Phase 3 appear to have had minimal effect on improving the performance of the KazETS. Allowing over-the-counter trading appears to have had no effect on the volume of transactions; the changes to the MRV system were not substantial; and lax benchmarks provided few incentives for CO2-intensive firms to invest in energy- or carbon-efficient technology or transition from coal to gas.

## 4. Conceptual framework

To evaluate the effectiveness of the KazETS, we use a conceptual framework that shares common features with [64,65]. Our analysis is based on the *transmission mechanisms* of climate policy on carbon emissions via pass-on of carbon prices; fuel substitution; technology adoption, new entrants, and government support (see Fig. 2). Using this framework, our objective is to evaluate, in a relative manner, Kazakhstan's experience with its ETS in the following areas: (1) the level of development of the CO2 market; (2) prices of energy; (3) the level of investment in the power sector; (4) changes in economy-wide and sector-level CO2 emissions; and (5) the emissions intensity of the power sector and the overall economy. Analysis of the impact of ETS on aggregate output, employment, and general prices is beyond the scope of our study.

### *4.1. Cost pass-on*

Technological updates and fuel switching by ETS firms require time. In the short run, the cost push from the introduction of carbon pricing will result in cost "pass-on" as ETS firms would raise their output price. The extent to which ETS compliance costs may be passed on to ETS firms' customers is determined by price elasticities of demand from other firms and final consumers. Thus, carbon prices progress through supply chains in the form of price increases of non-ETS goods. Due to an income effect, rising ETS-industry prices will reduce the disposable income of consumers, aggregate demand may (ceteris paribus) go down and carbon emissions will fall [66]. In the medium term, a substitution effect will result in intermediate and final consumers reducing their consumption of ETS industries' output by substituting to low-carbon products and thus reducing emissions [66].

### *4.2. Fuel substitution*

ETS firms may respond to the introduction of carbon pricing by substituting high carbon-intensive fuels (e.g., coal) by lower carbon-

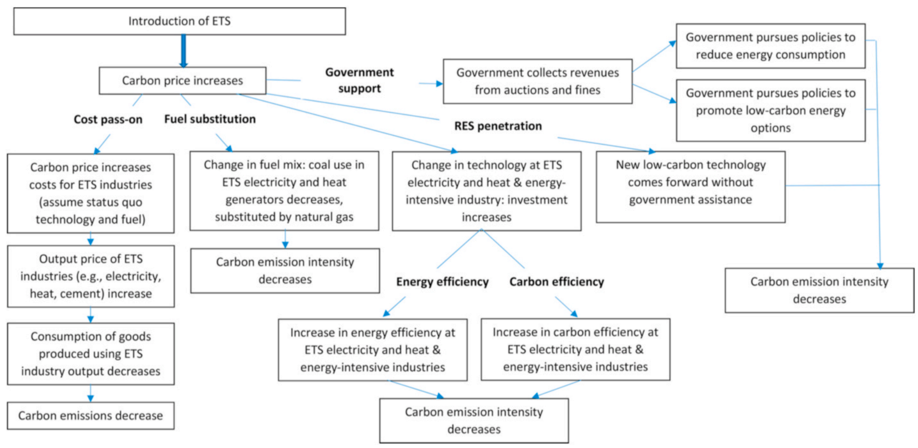


**Fig. 2.** ETS transmission mechanism.
Source: Based on [64,65] with authors' modifications

intensive fuels (e.g., natural gas). The ability to substitute energy types is constrained by technological characteristics of production as well as access to alternative energy types and reliability of supply.

### 4.3. Energy efficiency innovation

Firms may respond to carbon prices by increasing energy efficiency; that is, reducing overall energy consumption while maintaining output levels. Gains in energy efficiency require an adjustment to the production function through, for example, updating production processes or technology. The ability of firms to increase energy efficiency depends on the availability and affordability of modern technology, access to finance, and capability of implementing efficiency enhancing measures [65].

### 4.4. Carbon efficiency innovation

Coal- and natural gas-based facilities may produce significant CO2 reductions as a result of carbon efficiency improvements [67]. There are three main routes of CO2 technology systems: post-combustion, pre--combustion, and oxy-fuel combustion. Pre-combustion capture processes convert fuel into a gaseous mixture of hydrogen and CO2. The hydrogen is separated and can be burnt without producing any CO2. Post-combustion processes separate CO2 from combustion exhaust gases. Oxyfuel combustion processes use oxygen rather than air for combustion of fuel. This produces exhaust gas that is mainly water vapor and CO2 that can be captured [67]. According to David and Herzog [68]; the costs associated of $CO_2$ capture technology are an additional 1.5–2 $US cents per kWh and 3 $US cents per kWh to the cost of electricity for a natural gas-combined cycle power plant and coal power plant, respectively.

### 4.5. Renewable energy sources (RES) market penetration

Appropriate carbon pricing could lead to new low-carbon RES investment, which leads to RES sources having a greater share of total energy production and to a reduction in CO2 emissions. Wind, solar, and distributed bio-energy sources are already competitive without subsidies [69,70], provided that site conditions are favorable and fossil fuel subsidies, if present, are counteracted by carbon pricing. In addition, not only new RES sources are likely to be brought on line, but existing RES sources will have an incentive to improve their carbon efficiency.

### 4.6. Government support policies

Carbon price signals may not create a sustainable support for low-carbon innovation and penetration. As a result, government support policies, financed by revenue from carbon permit auctions, may be necessary. According to Wiese, Cowart and Rosenow [71] carbon permit revenue should be allocated to firms in sectors both covered by and outside the ETS. Recycling revenues has the ability to result in significant emission reductions at the lowest economic and societal costs because ETSs are commonly implemented into markets with second-best problems, e.g. market failures and barriers, which rationalize the use of multiple policies with a common policy target [72,73]. Furthermore, there is evidence from multiple jurisdictions that carbon pricing cannot, by itself, attract sufficient public support to drive down emissions enough to meet global carbon targets [74,75]. However, the public's willingness to support carbon pricing is greatly enhanced where the revenue is directed towards programs to reduce emissions, especially renewable energy [76]. The RGGI has demonstrated the political value of carbon revenue recycling to sustaining carbon pricing as a climate mitigation tool [77]. Well-planned and efficiently implemented government support schemes effectively contribute to renewable energy diffusion [78]. Furthermore, coordinated development of demand-side policies has the potential to greatly reduce carbon emissions. The full cost of saving electricity among U.S. utility efficiency programs was estimated at 4.6 $US cents per kWh [79]. The OECD [80] estimated that a US$ 25 carbon price in coal-intensive countries has the ability to generate fiscal revenues of one percent of the countries' GDP. These revenues can be plowed back into renewable energy and demand-side support schemes.

## 5. Assessing ETS outcomes

We provide both an absolute and a relative evaluation of the KazETS. The former is based on examining (1) the combined country-level annual carbon emissions factors for electricity and heat generation for the 2011–16 period, and (2) firm-level emissions factors for five ETS regulated electricity generating facilities for the 2011–16 period. The latter is based on our conceptual framework of the transmission mechanism, using publicly available data on a number of indicators before and after the introduction of emissions trading. In addition, we use outcomes of the EU-ETS for comparison as these are well researched and features of the two schemes are similar in many respects (See [116]). Furthermore, both the EU-ETS and KazETS were implemented and pilot phases operated during periods of high rates of GDP growth. In addition, Phase 2 of each system coincided with years of very low, and negative for the EU-ETS, GDP growth. As a result, the macroeconomic conditions that both ETSs experienced are quite similar.

### 5.1. Investigating absolute effects of the KazETS

Caution must be used when comparing 2011–2013 and 2014–2016 CO2 emission values as the method of calculating CO2 emissions changed. Prior to 2014, each coal-fired electricity and heat facility used a single country-wide coefficient that was based on the weighted average (by weight of individual coal mine production for the domestic market) of mine-specific CO2 emission coefficients. At the beginning of Phase 2, the system was changed so that individual facilities could choose between the country-wide emissions coefficient and a facility-specific coefficient calculated by using the weighted average of the specific mines' CO2 emission coefficients related to the coal which the facility consumed. As facilities which used poor quality coal most likely chose the country-wide coefficient, reported CO2 emissions are likely biased downwards after 2013. Based on annual emissions data for electricity and heat generated by fossil fuels [115] and total electricity and heat production data from the Kazakhstan Committee on Statistics [126], Kazakhstan's country-level carbon emissions factor for electricity and heat was 0.385 tons of CO2 per MWh in 2011 and steadily increased to 0.476 tons of CO2 per MWh in 2016.

Annual facility-level carbon emissions factors were estimated using facility-level electricity production [113] and facility level CO2 emissions data [124]. Again, caution must be used when comparing 2011–2013 CO2 emission values and 2014–2016 values. The average carbon intensity of coal-fired electricity facilities during 2016 was 0.952 tons per MWh down from 0.978 tons per MWh in 2011. However, each facility experienced significant reductions in their carbon emissions factors between 2013 and 2014 (2.1%–10.0%) and increases in their carbon emissions factors between 2014 and 2015 (1.0%–5.6%), which suggests these facilities most likely switched to facility-specific coefficients and actual CO2 reductions were less than reported. The average carbon intensity of natural gas-fired electricity facilities for 2016 was 0.755 tons per MWh down from 0.788 tons per MWh in 2011. However, again there was a large decrease in average carbon emissions factors between 2013 and 2014 (8.1%) and increase in the average carbon emissions factor between 2014 and 2015 (3.7%). These data suggest that the KazETS provided little incentive for facilities to invest in either energy efficiency or carbon efficiency, except for an electricity-generating facility owned by Eurasian Resource Group (ERG), an integrated international mining/metallurgy company, which experienced a 10% reduction in carbon intensity between 2013 and 2014. This reduction is aligned with ERG's carbon management plan, which has a goal of reducing the company's carbon footprint by 3% in response to international stakeholders' requests (personal communication with ERG management).

### 5.2. Investigating relative effects of the KazETS

We start with the consideration of emission levels in Kazakhstan and the EU: in the EU, CO2 emissions from electricity and heat sectors fell at an average of 1.1% per year over 2005–2016 [115]. It is important to note that this emissions reduction may not be directly attributable to the effect of the EU-ETS as other confounding factors, such as the economic recession associated with the financial crisis of 2007–09 need to be accounted for. In contrast, in Kazakhstan CO2 emissions from the electricity and heat sectors continued to grow after the introduction of its ETS, even though Kazakhstan experienced a sharp reduction in GDP growth during 2015–2016 (See Fig. 3). Specifically, the growth rate of CO2 emissions from the power sector decreased from an average of 5% per year during 2000–12 to 2.3% per year on average during 2013–17.

This reduction in emissions growth rate may be considered as aligning with an interpretation of ETS effectiveness vis-a-vis the business-as-usual scenario, i.e. if Kazakhstan's economy continued its high growth rates recorded prior to the collapse of petroleum prices in 2013–14. However, given Kazakhstan's poor macroeconomic performance during 2014–2016, we need to consider CO2 emissions in relative terms using intensity indicators. We observe that CO2 *emissions intensity* of GDP decreased at 2.8% per year during 1990–2012 (See Fig. 4). A key factor that contributed to this long-term reduction in emission intensity of GDP was the changing structure of production as the share of services increased from 25% to 56% of GDP between 1992 and 2018 [81]. However, after the KazETS was launched the emissions intensity of GDP reversed its trend and started growing at 1.2% per year during 2013–18. Furthermore, the introduction of the KazETS did not change the 20-year positive trend in emissions intensity of the largest contributor of Kazakhstan's CO2 emissions, the power sector.

As we take a closer look at the power sector itself, we note that Kazakhstan's fuel mix in power generation remains to be dominated by coal, which is similar to what it was in Germany: in late 1990s-early 2000s over 50% of Germany's electricity was produced from coal, but by 2018 this share went down to 35%. According to Grubb et al. [5], during Phase 1 of the EU-ETS utilities switched operations from less efficient brown coal to highly efficient hard coal plants. During Phase 2, there is evidence that utilities switched to using gas instead of coal to reduce their emissions [5]. In Kazakhstan, over 70% of its electricity generation has been historically attributed to coal and, despite the introduction of the KazETS, coal's share in Kazakhstan's electricity production remains unchanged. Furthermore, unlike in the EU, 86% of the thermal coal consumed in Kazakhstan is bituminous coal (and this percentage was constant over 2011–2016) and there is minimal opportunity to switch to more efficient hard coal plants. However, there is an opportunity for Kazakhstan's utilities to switch to natural gas. But, the Kazakhstan government's regulation of the wholesale and retail gas prices has led both foreign and local lenders and investors to ignore developing new gas fields and proceed with the gasification.

To provide further insight of the impact of the KazETS and EU-ETS, we examine the time series (1990–2018) of GHGs from the energy industries [82] for both jurisdictions. In 2005, the first year of Phase 1 of the EU-ETS, the level of GHGs emitted by the EU's energy industries was 95.5% of the level in 1990. This value increased to 96.6% in 2007, the last year of Phase 1. The Great Recession greatly reduced the level of energy industries emissions as the values decreased to 92.1% and 84.8% in 2008 and 2009, respectively. However, post 2009 the EU-ETS appears to have contributed to constraining the level of GHGs emitted in the EU as by 2018 the level of energy industries emissions reduced to only 66.6% of 1990 levels. For the KazETS, in 2013, Phase 1, the level of GHGs emitted by Kazakhstan's energy industries was 81.1% of the level in 1990. The level decreased to 76.0% in 2015, a year when Kazakhstan experienced 1.1% GDP growth. Post 2015, the level of energy industries emissions steadily grew so that by 2018 the level was 88.8% of the 1990 level. These data suggest that the KazETS, unlike the EU-ETS, did not assist in constraining the growth of GHG emissions when economic recovery resumed.

Now, we turn to considering Kazakhstan's *carbon market*. As Convery and Redmond [83] state "the market fundamentals of the [carbon allowance] market should be the same as for other commodity markets, supply and demand" ([83], p. 100). However, this assumes that firms and government are experienced in using economic instruments in climate policy and capable of both adapting these policies to local conditions and implementing these policies. During both Phase 1 and Phase 2, KazETS trading activity was thin as only 0.8% and 1.3% of total allocated emissions were traded in 2014 and 2015, respectively [31]. These values are extremely low in comparison to values reported by the EU-ETS. For the first three years of operation of the EU-ETS annual transactions were equivalent to almost 43% of the annual emissions cap [84]. The low trading volume at the KazETS may be attributed to the following: firms received additional carbon allowances if they introduced a new source of emissions or increased capacity; the MRV used by many firms did not comply with international standards [53]; violation penalties were commonly waived; brokers controlled trades which led to non-transparent pricing; a grandfathering process for allowance allocation was used and high emitting facilities were rewarded for past

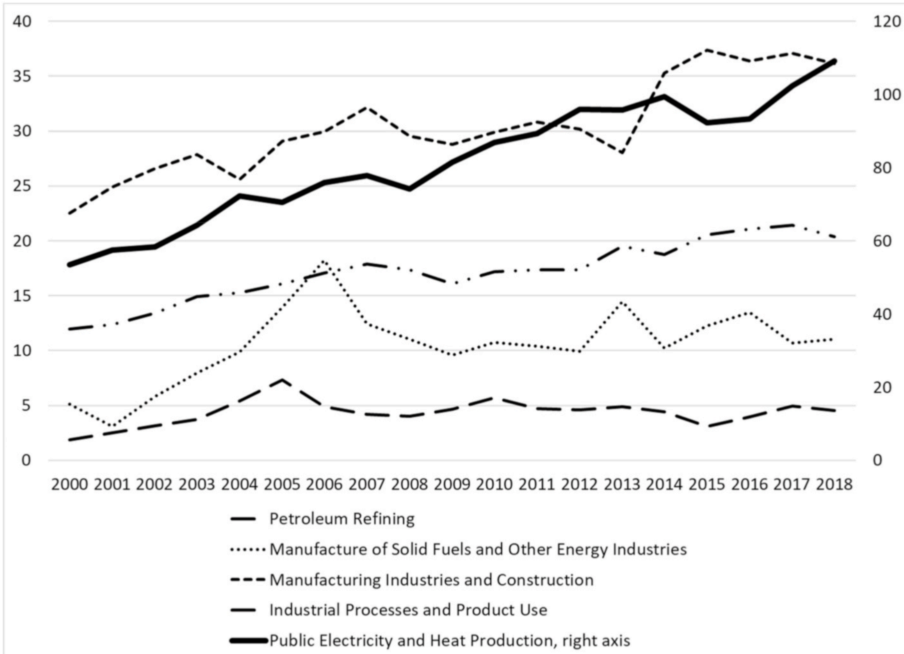


**Fig. 3.** CO2 emissions from sectors covered by the KazETS, Mt.
Source: [123].


**Fig. 4.** CO2 intensity of GDP and the power sector.
Sources: [90,118,123].

inefficiencies; national offset market was poorly developed; there was no market maker to improve liquidity [59]; and economic activity was low in 2015 which led many facilities to emit less than in 2014 [124].

As far as the *carbon price*, the volume-weighted average price per ton of CO2 for the KazETS in 2014 was $US 0.79 and $US 2.01 in 2015 [31]. Price volatility during both 2014 and 2015 was significant with prices ranging from $US 0.06 and $US 4.54 in 2014 and $US 0.05 to $US 8.10 in 2015 [31]. Again, the low prices and high volatility may be due, in part, to weak economic growth in 2015. Phase 3 trading commenced on Caspy in December 2019 and IHS Markit estimates that around 7.35 million tons of CO2 were traded, either on Caspy or over-the-counter [63]. Eleven transactions took place at the designated exchange [63]. Forty-seven trades were over-the-counter transactions – prices of these transactions were undisclosed [85]. However, Kazenergy [63] reports that the average price for these over-the-counter transactions was $US 1.2. In comparison, the average price per ton of CO2 for the EU-ETS was €10.08 for Phase 1 and €14.17 for Phase 2 [86,108]). Whereas, the minimum and maximum prices were €0.02 and €29.75 for Phase 1 and €6.16 and €28.25 for Phase 2 [86,87].

Now let us consider the effect of the ETS on *electricity prices*. In the

EU, electricity prices rose during the two initial phases of the EU-ETS: e.g., during 2005–12 real electricity prices in Germany increased by around 3% per year. Studies attribute these rising electricity prices in EU to 60–100% pass-through of costs of EU carbon allowances that power producers initially received for free and thus accumulated substantial windfall profits that they pledged to invest in technology upgrades [88, 89]. As far as Kazakhstan, carbon cost pass-through was explicitly prohibited. Prior to the KazETS, electricity prices rose faster than general consumer prices: during 2010–2013 real consumer and producer prices for electricity rose on average at 5.5% and 3.3% per year, respectively [90]. However, during 2014–18 real consumer and producer electricity prices declined at 2.5% and 2.6% per year, respectively. Moreover, in 2019 not only did real electricity prices decrease they fell even in nominal terms. This may be related to the fact that 2019 was a special year in Kazakhstan's history as it was its first experience with transition of political power since its 1991 independence. After 28 years of being the first president, Nursultan Nazarbayev stepped down and Kassym-Jomart Tokayev became the second president of Kazakhstan. During transition, the country's leadership wished to minimize any threat to political stability during the transition period. An increase in the tariffs for heat and electricity could have caused unrest and, therefore, was avoided.

Finally, we take a closer look at *investment in the power sector*: this analysis is important because according to the Government of Kazakhstan's Concept of Development of the Energy Complex by 2030 carbon prices were to stimulate investment in the development and introduction of both more efficient and more environmentally-friendly technologies [42]. We find that growth rates of power sector investment declined from an annual average of 13% during 2007–2014 to −7% during 2015–2018. In other words, the data suggest that the introduction of the KazETS was not associated with increased investment in the power sector. However, determining the actual impacts of the KazETS on investment is near to impossible and beyond the scope of our analysis. Nevertheless, we can state that there was no investment concurrent with or following the KazETS introduction, which perhaps indicates KazETS failure in this regard. Electricity price cap regulation, inability to pass costs of ETS compliance to power consumers, and the deterioration of the macroeconomic situation in 2014–16 likely contributed to falling levels of power sector investment. On the one hand, this observation is similar to the findings from the earlier studies of EU-ETS which reported that low-carbon investment was not perceived as priority by EU-ETS regulated firms [91,92] due to the effects of the credit crisis associated with the Great Recession. Laing et al. [93] attribute this muted impact of the EU-ETS on investment to low stringency of the EU-ETS and low carbon allowance prices that resulted from the over-allocation of EU carbon permits. On the other hand, later studies documented an increase in low-carbon patenting activities of EU-ETS regulated firms when compared to their non-regulated peers [94]. This differs from what was experienced in Kazakhstan as suggested by electricity-industry patents data, which indicate there were no significant differences in the annual number of electricity-industry patents between the 7 years before the implementation of the KazETS and the 2013–2018 period (Phases 1 and 2) [95].

To conclude, our analysis of the dynamics of several economic indicators before and after the introduction of the KazETS suggests mixed results. On the one hand, there is an indication of a reduction in the growth rate of annual CO2 emissions from the relevant sectors, primarily on the account of the power sector. On the other hand, CO2 emissions intensity of GDP increased during 2013–17 reversing its long-term downward trend, while CO2 emissions intensity of the power sector (See Fig. 4) continued its upward trend even after the introduction of the KazETS. These results for the KazETS are less impressive when compared to 2.0% average annual decrease of total CO2 emissions and a 1.1% average annual decrease in CO2 emissions from the EU power sector [115] between 2005 and 2016.[2,3] Furthermore, the level of investment in Kazakhstan's power sector has been falling since 2014 alongside inflation-adjusted electricity prices as well as there has been no change in the level of innovations. These findings contrast the ones observed in the EU, where rising electricity prices and increased low-carbon innovation in the power sector were documented. Finally, EU-ETS studies did not find convincing evidence of a negative impact of the ETS on employment, exports, and firm downsizing or relocation [96]. In Kazakhstan, the pass-on effects of the KazETS on energy consumers have been deactivated because the cost pass-through transmission mechanism via increasing electricity and heat prices was disabled by Kazakhstan's government regulations. It is important to highlight that even if policy conditions were ever to lead to a carbon price increase, a policy which prohibits the pass-through of a portion of the costs of carbon allowances could lead the former policies to be ineffective or have negative side effects [97]. Furthermore, because of the absence of indirect emissions regulations (often referred to as Inclusion of Consumption regulations) for large electricity and heat consumers [59], large electricity consumers fail to adopt best available technologies [98]. In addition, lax benchmarks and the ability to choose allowance allocations by grandfathering have reduced the incentives for fuel substitution. Finally, free allocation of allowances has inhibited recycling of revenues towards RES and demand-side policies as well as increasing public support to decrease emissions enough to meet global carbon targets.

## 6. Conclusions and policy implications

There are multiple challenges of successful implementation of an ETS, some of them are common to both high-income and emerging economies, while others are relevant primarily for the latter. In Kazakhstan as well as in the EU, deteriorating macroeconomic conditions undermined firms' abilities to access capital necessary for innovation and investment. In addition, economic crises and falling output levels rendered emission caps non-binding, resulting in low ETS allowance prices that provided few incentives for abatement and investment. However, Grubb et al. [5] indicate that expectations are an important factor for ETS-regulated facilities. The authors state that "analyses strongly suggested that the EU-ETS was the biggest single influence ensuring that emissions in [2008] stayed below the (annual) cap set for Phase II" (ibid, p. 244) even though 2008 concurred with the Great Recession. However, Fig. 2 indicates that cost pass-on is only one transmission channel in which carbon prices can lead to reduced CO2 emissions. Other common channels for incumbent power plants include fuel substitution and technology upgrading. During Phase 1 of the EU-ETS, utilities switched operations from less efficient brown coal to highly efficient hard coal plants (ibid, 2014). During Phase 2, there is evidence that utilities switched to using gas instead of coal to reduce their emissions (ibid, 2014). Finally, evidence shows that CO2 savings during Phase 1 and 2 of the EU-ETS were almost all due to operational changes in existing stock even though industry "stressed that it cannot invest serious capital in low-carbon solutions based on a system in which prices have followed such a boom-and-bust pattern" (ibid p.248). Similar allowance price volatility occurred during Phase 2 of the KazETS; however, neither significant fuel substitution nor technology upgrading occurred in Kazakhstan's electricity and heat facilities.

An additional challenge experienced by the KazETS was the reality of highly regulated energy markets and a complex system of energy

[2] The CO2 emission values for Croatia are added to 2005 EU CO2 values when comparing to 2016 EU CO2 values.

[3] [121] estimate a 0.7% average annual decrease in CO2 emissions for the EU-ETS.

subsidies that created multiple distortions. In such an environment, power companies were unable to pass-through the costs of compliance. However, higher prices are necessary "since it is ultimately the consumer who demands too much of a product that is underpriced" [99]; p.37). In fact, in 2019 power prices in Kazakhstan were set at 30–40% below cost-recovery levels resulting in significant losses for power producers that reported problems with covering even their operating costs [100]. These statements are confirmed by our findings of falling real electricity prices and dwindling power sector investments. We do find some evidence of a slowdown of the growth rate of CO2 emissions from the power sector during KazETS Phase 1 and 2 and the subsequent intermission period, which may be partially attributed to the positive effect of Kazakhstan's climate policy. However, it is unlikely that the performance of the KazETS during Phase 3 covering 2018–2020 will improve. First, the 2019 transition of political power heightened the leadership's objective to preserve a social contract based on redistributive policies and price controls [101]. Second, deteriorating macroeconomic conditions in 2020 stemming from the collapse of the price of oil, Kazakhstan's major export item, and the COVID-19 pandemic may have long-term impacts on Kazakhstan's power industry by changing priorities from climate policy to energy security to energy self-sufficiency [102]: increasing the government's control over energy tariffs and investment; increasing the share of traditional coal-fired generation, and reducing the focus of the government on promoting renewable energy [103]. As a result, to ensure long-term effectiveness of the country's ETS and the ability to reach the country's 2030 goal of 15% decrease in GHG emissions, Kazakhstan's government should address the problem of distortions in energy pricing which undermine the transmission mechanism of its ETS-based climate policy.

In general, the analysis of lessons learned from Kazakhstan's ETS experience enables us to make policy recommendations for middle-income countries planning to introduce ETS. These recommendations are listed below in the order of priority, as well as acceptability to stakeholders and impact on government expenditures.

1. Stakeholder engagement and communication in policy development, implementation and assessment are crucial. The initial phase of the ETS should be multi-year and used as a learning phase. Furthermore, ongoing engagement and communication with industry is essential so that government decisions and regulations will be accepted by industry and mitigate concerns surrounding compliance.
2. Prohibit over-the-counter trading of emission allowances to promote both liquidity and efficient price discovery.
3. If allowances are allocated by benchmarking, then establish a set of benchmarks that are based on the emissions of the most carbon-efficient firms or set according to best available technologies; thereby, incentivizing CO2-efficiency investments as well as fuel substitution.
4. Implement an allowance auction system that enables recycling of revenues to finance RES and demand-side policies as well as increase public support.
5. Enable some form of pass-through of costs of compliance to final consumers to enable firms to upgrade or replace outdated technology as well as promote energy saving and efficiency in the wider economy. If cost pass-through is politically unacceptable, consider implementing indirect emission regulations for large electricity and heat consumers similar to what Korea is doing [31].
6. Implement energy subsidy reform – the gradual elimination of subsidies should start during a period of lower energy prices as the effective subsidy is low.
7. Reduce state presence and increase competition in relevant sectors prior to and after the launch of an ETS – "State-owned enterprises face conflicts of interest that stem from a government's dual role as an owner, operator and businessman on the one hand and as the protector of the public interest and therefore a regulator of the SOE on the other hand" [104]; p. 11). Decreasing the SOEs' share of economic activity is in line with the government of Kazakhstan's privatization target of SOE's share to 15% of GDP by 2020 [127] and the Comprehensive Privatization Plan for 2021–2025 [105].

These seven recommendations should be coordinated and implemented jointly with policies related to energy efficiency standards/public engagement and low carbon technology/infrastructure development to enable a multi-faceted approach to low-carbon transition. It is important to note an advantage of an ETS over a carbon tax system in fossil-fuel dependent economies – the former's stabilizing effect on economic activity with low allowance prices prevailing in periods of low energy prices when emissions are low and high allowance prices in periods of high oil prices when emissions are high. This inherent price correlation between energy price and allowance price needs to be communicated by government policymakers to market players to secure long-term support for an ETS. It is noteworthy to mention that in net-oil importing emerging and developing economies (e.g., Ukraine, Argentina), a carbon tax system may be more appropriate because of a likely negative correlation between oil prices and CO2 allowance prices. Finally, government should evaluate the adoption of risk contingencies (e.g., physical and financial price risk management instruments) as they may be important for adjusting to changing macroeconomic situations which are particularly rapid and severe in resource export-oriented economies.

To conclude, our study presents initial findings on the effectiveness of ETS-based climate policy in a fossil fuel-dependent country, based on macroeconomic and industry level indicators. Our research on Kazakhstan's ETS demonstrates that climate policy in a fossil fuel-dependent country is highly vulnerable to changes in international energy markets, as well as pressures from the vested interests of large SOEs and private companies. Our findings may be further refined if this study is extended by analyzing firm-level experience with adopting an ETS in a country with a large extractive sector, state ownership of key assets, and tight control of the energy sector. This would allow policy makers to identify firm-level administrative, financing, and managerial constraints that need to be considered in designing an ETS in the context of a fossil fuel-dependent economy.

## Author Contributions

Conceptualization, Peter Howie and Zauresh Atakhanova; Methodology, Peter Howie and Zauresh Atakhanova; Validation, Peter Howie and Zauresh Atakhanova; Formal analysis, Peter Howie and Zauresh Atakhanova; Investigation, Peter Howie and Zauresh Atakhanova; Resources, Peter Howie and Zauresh Atakhanova; Data curation, Zauresh Atakhanova; Writing—original draft preparation, Peter Howie and Zauresh Atakhanova; Writing—review and editing, Peter Howie and Zauresh Atakhanova; Visualization, Peter Howie and Zauresh Atakhanova; Supervision, Peter Howie and Zauresh Atakhanova; Project administration, Peter Howie and Zauresh Atakhanova. Peter Howie took the lead in writing the manuscript. All authors provided critical feedback and helped shape the research, analysis and manuscript. All authors have read and agreed to the published version of the manuscript.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## References

[1] F. Van Der Ploeg, C. Withagen, Too much coal, too little oil, J. Publ. Econ. 96 (1–2) (2012) 62–77.
[2] F. Van der Ploeg, C. Withagen, Growth, renewables, and the optimal carbon tax, Int. Econ. Rev. 55 (1) (2014) 283–311.

[3] H. Park, Factors to enhance reduction technology development through ETS, Energy Strategy Rev. 29 (2020), https://doi.org/10.1016/j.esr.2020.100489.
[4] International Carbon Action Partnership (ICAP), Emissions Trading Worldwide: Status Report 2020, ICAP, 2020.
[5] M. Grubb, J.C. Hourcade, K. Neuhoff, Planetary economics: energy, climate change and the three domains of sustainable development. Routledge. https://climatestrategies.org/wp-content/uploads/2014/11/Planetary-economics-slides-complete.pdf, 2014.
[6] R. Baldwin, Regulation lite: the rise of emissions trading, Law Financ market Rev. 2 (3) (2008) 262–278.
[7] International Monetary Fund (IMF), Commodity price swings and commodity exporters, April, in: World Economic Outlook, IMF Publication Services, Washington, DC, 2012, https://www.imf.org/~/media/Websites/IMF/imported-flagship-issues/external/pubs/ft/weo/2012/01/pdf/_c4pdf.ashx.
[8] A. Shangle, S. Solaymani, Responses of monetary policies to oil price changes in Malaysia, Energy 200 (2020) 117553.
[9] E. Haites, Carbon taxes and greenhouse gas emissions trading systems: what have we learned? Clim. Pol. 18 (8) (2018) 955–966.
[10] M. Muûls, J. Colmer, R. Martin, U.J. Wagner, Evaluating the EU Emissions Trading System: take it or leave it? An assessment of the data after ten years. Grantham Institute briefing paper, 21. https://www.imperial.ac.uk/media/imperial-college/grantham-institute/public/publications/briefing-papers/Evaluating-the-EU-emissions-trading-system_Grantham-BP-21_web.pdf, 2016.
[11] V. Nee, S. Opper, Capitalism from below: Markets and Institutional Change in China, Harvard University Press, Cambridge, Massachusetts, 2012.
[12] G. Peszko, D. van der Mensbrugghe, A. Golub, J. Ward, D. Zenghelis, C. Marijs, A. Schopp, J.A. Rogers, A. Midgley, Diversification and Cooperation in a Decarbonizing World: Climate Strategies for Fossil Fuel-dependent Countries, World Bank, Washington, DC, 2020.
[13] United Nations Framework Convention on Climate Change (UNFCCC), 1992. June 13, 1992, 1771 U N.T S. 107.
[14] World Bank, World Bank development indicators: GDP per capita (current US $) and population — Kazakhstan, Retrieved September 4, 2021, from, https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=KZ_and_https://data.worldbank.org/indicator/SP.POP.TOTL?locations=KZ, 2021.
[15] International Energy Agency (IEA), Kazakhstan country profile. https://www.iea.org/countries/Kazakhstan, 2020.
[16] International Monetary Fund (IMF), Republic of Kazakhstan. 2019 Article IV Consultation – Press Release; and Staff Report (IMF Country Report 20/32), 2020.
[17] N. Stern, Stern Review on the Economics of Climate Change, HM Treasury, London, 2006.
[18] P. Drummond, P. Ekins, Reducing CO2 emissions from residential energy use, Build. Res. Inf. 44 (5–6) (2016) 585–603.
[19] J.F. Mercure, H. Pollitt, U. Chewpreecha, P. Salas, A.M. Foley, P.B. Holden, N. R. Edwards, The dynamics of technology diffusion and the impacts of climate policy instruments in the decarbonisation of the global electricity sector, Energy Pol. 73 (2014) 686–700.
[20] A. Khokhlov, Y. Melnikov, Coal Generation: New Challenges and Opportunities, Energy Center of the Moscow School of Management, Skolkovo, 2019. https://energy.skolkovo.ru/downloads/documents/SEneC/Research/SKOLKOVO_EneC_Coal_generation_2019.01.01_Rus.pdf.
[21] United Nations Economic Commission for Europe (UNECE), Environmental performance reviews: Kazakhstan, third review. https://unece.org/environment-policy/publications/3rd-environmental-performance-review-kazakhstan, 2019.
[22] United Nations Development Programme (UNDP), Republic of Kazakhstan: energy-efficient design and construction of residential buildings – midterm evaluation report. https://info.undp.org/docs/pdc/Documents/KAZ/MTE%20report%20EE%20buildings%20FINAL%2074950.docx, 2013.
[23] World Bank, Kazakhstan: energy efficiency transformation in Astana and Almaty. https://documents1.worldbank.org/curated/en/362411510931587832/pdf/121462-ESM-P130013-PUBLIC-KEEPAstanaEEPlanNovengfinal.pdf, 2017.
[24] Eurostat, Electricity price statistics. https://ec.europa.eu/eurostat/databrowser/view/ten00117/default/table?lang=en, 2021.
[25] Eurostat, Gas prices by type of user. https://ec.europa.eu/eurostat/databrowser/view/ten00118/default/table?lang=en, 2021.
[26] A. Laskey, O. Kavazovic, Energy efficiency through behavioral science and technology, XRDS 17 (4) (2011).
[27] Kazenergy, The national energy report. http://www.kazenergy.com/upload/document/energy-report/NationalReport19_en.pdf, 2019.
[28] Kazenergy, The national energy report. www.kazenergy.com/en/analyst/783/, 2017.
[29] PwC Kazakhstan, The renewable energy sources market in Kazakhstan: potential, challenges, and prospects. https://www.pwc.com/kz/en/assets/pdf/esg-dashboard-eng.pdf, 2021.
[30] N. Temirgaliyeva, M. Junussova, Renewable electricity production and sustainability of the national and regional power systems of Kazakhstan, silk road, J. Eurasian Develop. 2 (1) (2020) 35–53.
[31] P. Howie, S. Gupta, H. Park, D. Akmetov, Evaluating policy success of emissions trading schemes in emerging economies: comparing the experiences of Korea and Kazakhstan, Clim. Pol. 20 (5) (2020) 577–592.
[32] European Bank of Reconstruction and Development (EBRD), Transition report 2020-21: the state strikes back. https://www.ebrd.com/news/publications/transition-report/transition-report-202021.html, 2020.
[33] S.J. Commander, R. Prieskienyte, The political economy of Kazakhstan: a case of good economics, bad politics? IZA institute of labor economics discussion paper No. 14554. https://ftp.iza.org/dp14554.pdf, 2021.
[34] M. Aldayarov, I. Dobozi, T. Nikolakakis, Stuck in Transition: Reform Experiences and Challenges Ahead in the Kazakhstan Power Sector, The World Bank, 2017.
[35] World Bank, Kazakhstan: Support to Energy Efficiency Transformation in Cities, 2016.
[36] Z. Atakhanova, P. Howie, Electricity demand in Kazakhstan, Energy Pol. 35 (7) (2007) 3729–3743.
[37] Nordea, Tax rates in Kazakhstan. www.nordeatrade.com/en/explore-new-market/kazakhstan/taxes, 2020.
[38] BP, BP statistical review of world energy June 2019. http://www.bp.com/statisticalreview, 2019.
[39] S. Pirani, Central Asian Gas: Prospects for the 2020s, Oxford Institute for Energy Studies Paper, 2019. NG 155.
[40] International Energy Agency (IEA), World Energy Outlook 2014, OECD/IEA, 2014. www.iea.org/publications/freepublications/publication/WEO2014.pdf.
[41] International Energy Agency (IEA), Clean Energy Technology Assessment Methodology Pilot Study: Kazakhstan, OECD/IEA, 2016.
[42] A. Boute, The impossible transplant of the EU Emissions Trading Scheme: the challenge of energy market regulation, Trans. Environ. Law 6 (1) (2017) 59–85.
[43] P. Howie, Z. Atakhanova, Household coal demand in rural Kazakhstan: subsidies, efficiency, and alternatives, Energy Pol. Res. 4 (1) (2017) 55–64.
[44] M.B.J. Clements, D. Coady, M.S. Fabrizio, M.S. Gupta, M.T.S.C. Alleyne, M.C. A. Sdralevich, Energy Subsidy Reform: Lessons and Implications, International Monetary Fund, 2013.
[45] D. Manley, J.F. Cust, G. Cecchinato, Stranded Nations? the Climate Policy Implications for Fossil Fuel-Rich Developing Countries, OxCarre Policy Paper, 2017, p. 34.
[46] L. El-Katiri, B. Fattouh, A brief political economy of energy subsidies in the Middle East and North Africa. International Development Policy. https://doi.org/10.4000/poldev.2267, 2017.
[47] A. Gómez, C. Dopazo, N. Fueyo, The causes of the high energy intensity of the Kazakh economy: a characterization of its energy system, Energy 71 (2014) 556–568.
[48] Organization of Economic Cooperation (OECD), GHG emissions from fuel combustion (summary). IEA CO2 emissions from fuel combustion statistics: greenhouse gas emissions from energy (database). https://ezproxy.nu.edu.kz:2122/10.1787/445ec5dd-en, 2021.
[49] European Commission, EDGAR – Emissions Database for Global Atmospheric Research, 2019.
[50] KEMA, Kazakhstan Generation Roadmap: Component 2: Conceptual Solution. Analysis of Adopted Capacity Market Model and Description of its Functioning, DNV GL Group, 2013.
[51] Asian Development Bank, Economics of climate change in central and west Asia. https://doi.org/10.22617/RPT178634, 2017.
[52] United Nations Framework Convention on Climate Change (UNFCCC), Report on the technical review of the fourth biennial report of Kazakhstan. https://unfccc.int/sites/default/files/resource/trr4_KAZ.pdf, 2021.
[53] D. Baigunakova, F. Gagelmann, D. Lewandrowski, Emissions Trading in Kazakhstan: Recommendations for Cap Setting, German Emissions Trading Authority (DEHSt) at the German Environment Agency, 2017.
[54] Government of Kazakhstan, Decree of the Republic of, Kazakhstan Government on the Development of the Fuel-Energy Complex by 2030 (No. 724), 2014.
[55] S. Shim, J. Lee, Covering indirect emissions Mitigates market power in carbon markets: the case of South Korea, Sustainability 8 (6) (2016) 583.
[56] Z. Atakhanova, Kazakhstan's oil boom, diversification strategies, and the service sector, Mineral Econ. 34 (2021) 399–409.
[57] International Carbon Action Partnership (ICAP), Kazakhstan Emissions Trading Scheme – 3 June 2020 Update, 2020.
[58] Partnership for Market Readiness (PMR), PMR Project Implementation Status Report (ISR) – Republic of Kazakhstan, 2019.
[59] P. Howie, I. Yesdauletov, Y. Dyussenov, Support for nuclear power in Central Asia: examining historical and spatial separation, Post Commun. Econ. 32 (7) (2020) 947–968.
[60] Kazakhstan Ministry of Energy, On approval of the list of specific GHG emission factors. http://adilet.zan.kz/rus/docs/V1700015396, 2017.
[61] M. Pahle, L. Fan, W.P. Schill, How emission certificate allocations distort fossil investments: the German example, Energy Pol. 39 (4) (2011) 1975–1987.
[62] Environment and Climate Change Canada, Pan-Canadian Approach to Pricing Carbon Pollution: Interim Report 2020, 2021. https://publications.gc.ca/collections/collection_2021/eccc/En4-423-1-2021-eng.pdf.
[63] KazEnergy, A possible scenario for achieving carbon neutrality until 2060 was discussed at a meeting of the Coordinating Council for the Development of the Electric Power Industry of KAZENERGY Association. https://www.kazenergy.com/en/press-center/news/2440/, 2021.
[64] S. Akbar, G. Kleiman, S. Menon, L. Segafredo, Climate-smart Development: Adding up the Benefits of Actions that Help Build Prosperity, End Poverty and Combat Climate Change, International Bank for Reconstruction and Development/The World Bank and ClimateWorks Foundation, 2014.
[65] J. Rentschler, M. Kornejew, M. Bazilian, Fossil fuel subsidy reforms and their impacts on firms, Energy Pol. 108 (2017) (2017) 617–623.
[66] A. Ayarkwah, J. Mohammed, Fuel price adjustments and growth of SMEs in the new Juaben municipality, Ghana, Int. J. Small Business Entrepreneurship Res. 2 (3) (2014) 13–23.
[67] Global CCS Institute, Capturing carbon dioxide (CO2). https://www.globalccsinstitute.com/about/what-is-ccs/capture/, 2018.
[68] J. David, H. Herzog, The Cost of Carbon Capture, Fifth international conference on greenhouse gas control technologies, Cairns, Australia, 2000.

[69] International Renewable Energy Agency (IRENA), Renewable power generation costs in 2020. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/Jun/IRENA_Power_Generation_Costs_2020.pdf, 2021.
[70] C. Schultz, et al., Renewable Energy Trends, Options, and Potentials for Agriculture, Forestry, and Rural America, U.S. Department of Agriculture, 2021. https://www.usda.gov/sites/default/files/documents/renewable-energy-trends-2020.pdf.
[71] C. Wiese, R. Cowart, J. Rosenow, The strategic use of auctioning revenues to foster energy efficiency: status quo and potential within the European Union Emissions Trading System, Energy Efficiency 13 (8) (2020) 1677–1688.
[72] L.S. Bennear, R.N. Stavins, Second-best theory and the use of multiple policy instruments, Environ. Resour. Econ. 37 (1) (2007) 111–129.
[73] K. Gillingham, R.G. Newell, K. Palmer, Energy efficiency economics and policy, Annual Rev. Res. Econ. 1 (1) (2009) 597–620.
[74] B.G. Rabe, The durability of carbon cap-and-trade policy, Governance 29 (1) (2016) 103–119.
[75] B.G. Rabe, Can We Price Carbon? MIT, University Press, Cambridge, 2018.
[76] M. Fowlie, The Trouble with Carbon Pricing, Energy Institute at Haas, 2019. Retrieved from: https://energyathaas.wordpress.com/2019/04/29/the-trouble-with-carbon-pricing/.
[77] L. Raymond, Reclaiming the Atmospheric Commons: the Regional Greenhouse Gas Initiative and a New Model of Emissions Trading. MIT, University Press, Cambridge, 2016.
[78] M. Lehtovaara, Commercialization of Modern Renewable Energy. PhD Thesis, Lappeenranta University of Technology, Lappeenranta, Finland, 2013. https://lutpub.lut.fi/bitstream/handle/10024/94034/isbn9789522655233.pdf?sequence=2&isAllowed=y#page=13.
[79] S. Schiller, L. Schwartz, Coordinating Demand-Side Efficiency Evaluation, Measurement and Verification Among Western States: Options for Documenting Energy and Non-energy Impacts for the Power Sector, Lawrence Berkeley National Laboratory, 2016. https://escholarship.org/content/qt0ts084q6/qt0ts084q6.pdf.
[80] Organization of Economic Cooperation (OECD), Tax Policy and Climate Change, 2021. https://www.oecd.org/tax/tax-policy/tax-policy-and-climate-c hange-imf-oecd-g20-report-april-2021.pdf.
[81] P. Howie, Z. Atakhanova, Heterogeneous labor and structural change in low-and middle-income, resource-dependent countries, Econ. Change Restruct. 53 (2) (2020) 297–332.
[82] United Nations Framework Convention on Climate Change (UNFCCC), GHG data from UNFCCC. https://di.unfccc.int/time_series, 2021.
[83] F.J. Convery, L. Redmond, Market and price developments in the European Union emissions trading scheme, Rev. Environ. Econ. Pol. 1 (1) (2007) 88–111.
[84] European Commission, EU Action against Climate Change: the EU Emissions Trading Scheme, Office for Official Publications of the European Communities, 2009, p. 2013.
[85] Kursiv (news agency), in: Kazakhstan the Price of GHG Permits May Increase 15 Times, 2021. https://kursiv.kz/news/otraslevye-temy/2021-10/v-kazakhstane-stoimost-kvot-na-vybrosy-parnikovykh-gazov-mozhet.
[86] G. Daskalakis, D. Psychoyios, R.N. Markellos, Modeling CO2 emission allowance prices and derivatives: evidence from the European trading scheme, J. Bank. Finance 33 (7) (2009) 1230–1241.
[87] International Carbon Action Partnership (ICAP), Allowance Price Explorer, 2020.
[88] J. Sijm, K. Neuhoff, Y. Chen, CO2 cost pass-through and windfall profits in the power sector, Clim. Pol. 6 (1) (2006) 49–72.
[89] A.D. Ellerman, C. Marcantonini, A. Zaklan, The European Union emissions trading system: ten years and counting, Rev. Environ. Econ. Pol. 10 (1) (2016) 89–107.
[90] Kazakhstan Committee on Statistics, Consumer Prices in the Republic of Kazakhstan, 2020.
[91] M. Kenber, O. Haugen, M. Cobb, The Effects of EU Climate Legislation on Business Competitiveness: A Survey and Analysis (GMF Climate and Energy Paper Series 09), German Marshall Fund of the United States, 2009.
[92] P. Aghion, R. Veugelers, C. Serre, Cold Start for the Green Innovation Machine (Bruegel Policy Contribution 12). Bruegel Policy Contribution, 2009.
[93] T. Laing, M. Sato, M. Grubb, C. Comberti, Assessing the Effectiveness of the EU Emissions Trading System, Grantham Research Institute on Climate Change and the Environment, 2013. Working Paper 126.
[94] R. Calel, A. Dechezleprêtre, Environmental policy and directed technological change: evidence from the European carbon market, Rev. Econ. Stat. 98 (1) (2016) 173–191, https://doi.org/10.1162/REST_a_00470.
[95] Organization of Economic Cooperation (OECD), Patents by Technology - OECD Statistics, 2021. https://stats.oecd.org/Index.aspx?DataSetCode=PATS_IPC.
[96] R. Martin, M. Muûls, U.J. Wagner, The impact of the European Union Emissions Trading Scheme on regulated firms: what is the evidence after ten years? Rev. Environ. Econ. Pol. 10 (1) (2016) 129–148.
[97] J.P.M. Sijm, S. Hers, W. Lise, B.J.H.W. Wetzelaer, The Impact of the EU ETS on Electricity Prices, Energy Research Centre of the Netherlands, Petten, 2009. http://re.indiaenvironmentportal.org.in/files/e08007.pdf.
[98] K. Neuhoff, R. Ismer, W. Acworth, A. Ancygier, C. Fischer, M. Haussner, V. Zipperer, Inclusion of Consumption of carbon intensive materials in emissions trading – an option for carbon pricing post-2020. Climate Strategies. https://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2016/06/CS-Report.pdf, 2016.
[99] S.E. Weishaar, Emissions Trading Design: A Critical Overview, Edward Elgar Publishing, 2014.
[100] Y. Nikitin, Darkness at the End of a Tunnel: How Serious Are Problems of Kazakhstan's Power Sector? Zakon News Agency, 2020.
[101] N. Ibadildin, D. Pisareva, Central Asia in transition: social contract transformation in Nazarbayev and post-Nazarbayev Kazakhstan, in: Mihr Anja (Ed.), Transformation and Development, Springer, 2020, pp. 101–116.
[102] A. Boute, Energy Security along the New Silk Road: Energy Law and Geopolitics in Central Asia, Cambridge University Press, 2019.
[103] D. Akhmetov, P. Howie, COVID-19 and the Power Industry Response: the Case of Kazakhstan, IAEE Energy Forum, 2020. Covid-19 Issue 2020.
[104] J. Radon, J. Thaler, Resolving conflicts of interest in state-owned enterprises, Int. Soc. Sci. J. 57 (1) (2005) 11–20.
[105] Prime Minister of the Republic of Kazakhstan, By 2025, share of state participation in economy to be reduced to 14%. https://primeminister.kz/en/news/2025-zhylga-karay-memlekettin-ekonomikaga-katysu-ulesi-14-ga-deyin-kyskarady-a-smaylov-23828, 2021.
[106] McKenzie Baker, Doing business in Kazakhstan. https://www.bakermckenzie.com/en//-/media/files/insight/guides/2021/doing-business-in-kazakhstan-2021.pdf, 2021.
[107] P. Bayer, M. Aklin, The European Union Emissions Trading System reduced CO2 emissions despite low prices, Proc. Natl. Acad. Sci. Unit. States Am. 117 (16) (2020) 8804, https://doi.org/10.1073/pnas.1918128117.
[108] German Emissions Trading Authority (DEHSt), Auctions during the Second Trading Period (2008-2012), 2014.
[110] Government of Kazakhstan, On Approval of the Concept of Industrial-Innovative Development of the Republic of Kazakhstan for 2020 – 2025, 2019.
[113] Kazakhstan Electricity and Power Market Operator (KOREM) (various years). Annual Report. https://www.korem.kz/eng/about/godovye_otchety/.
[115] Organization of Economic Cooperation/International Energy Agency (OECD/IEA) (Various Years) CO2 Emissions from Fuel Combustion.
[116] F. Sammut, L.H. Gulbrandsen, J. Wettestad, Emissions trading in Kazakhstan: complicated application of the 'EU model.', in: The Evolution of Carbon Markets, Routledge, 2018, pp. 166–179.
[117] United Nations Development Programme (UNDP), Outcomes of an opinion survey on climate change and environmental issues. https://www.kz.undp.org/content/kazakhstan/en/home/presscenter/news/2020/may/outcomes-of-an-opinion-survey-on-climate-change-and-environmenta.html, 2020.
[118] World Bank (n.d.). World Bank Development Indicator: GDP, PPP (constant 2017 international $)—Kazakhstan. Retrieved June 20, 2020, from https://data.worldbank.org/indicator/NY.GDP.MKTP.PP.CD?end=2018&locations=KZ-1W&start=2000.
[120] World Nuclear Association, Uranium Production Figures, 2011-2020, 2021. http://www.world-nuclear.org/information-library/facts-and-figures/uranium-production-figures.aspx.
[121] Organization of Economic Cooperation (OECD). Reforming Kazakhstan: Progress, Challenges and Opportunities, OECD Publishing, 2018. https://www.oecd.org/eurasia/countries/OECD-Eurasia-Reforming-Kazakhstan-EN.pdf.
[122] Kazakhstan Electricity and Power Market Operator (KOREM). Annual Report 2019, KOREM, 2020. https://www.korem.kz/details/ndownload.php?fn=6025&lang=rus.
[123] United Nations Framework Convention on Climate Change (UNFCCC). UNFCCC GHG Data Interface, UNFCCC, 2020. https://di.unfccc.int/flex_annex1.
[124] Kazakhstan Ministry of Ecology, Geology and Natural Resources. CO2 Emissions for Regulated Facilities, Government of Kazakhstan, 2020.
[126] Kazakhstan Committee on Statistics. Manufacture of industrial products: supply of electricity, gas, steam, hot water and air conditioning in the Republic of Kazakhstan, Government of Kazakhstan, 2021. https://stat.gov.kz/api/getFile/?docId=ESTAT335382.
[127] United States Department of State. 2021 Investment Climate Statements: Kazakhstan, U.S. Bureau of Economic and Business Affairs, 2021. https://www.state.gov/reports/2021-investment-climate-statements/kazakhstan.