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Review article

The promotion of renewable energy technologies in the former Soviet bloc: Why, how, and with what prospects?

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ABSTRACT

The purpose of this study, which applies the policy cycle framework, is to ascertain why certain renewable energy policy aims being formulated in the former Soviet bloc (Azerbaijan, Kazakhstan, Russia, Georgia, Armenia, Ukraine, Moldova, and Poland), as well as to review what policy instruments are being used to promote renewable energy technologies. In addition, it reviews how the renewable energy sectors are progressing in the covered countries and determines what their prospects are for the future, bearing in mind the impact of the ongoing COVID-19 pandemic. With a global move toward a reduction in greenhouses gas emissions these countries are mandated to explore alternative or renewable energy supplies. Thus, command-and-control instruments have been established by a number of regulations and pieces of legislation such as laws on renewable energy development, guaranteed purchase by grid operators, and guaranteed grid interconnection. Market-based instruments have been established by imposing feed-in tariffs and offering tax incentives for renewables projects. As for information policy instruments, investor guides detailing renewable energy projects with corresponding estimates for wind, solar, biomass, and mini-hydro energy potentials are being developed. However, looking at the countries covered in this paper, Ukraine, Azerbaijan, Kazakhstan, and Russia might struggle to meet their long-term climate and energy targets. The analysis ultimately highlights policy implications for Soviet bloc countries including the need to enhance national laws on renewable energy projects, to revise feed-in tariff design models, to develop short-, medium-, and long-term renewable reserve funds, and to establish practical guidelines for national and international investors.

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Nomenclature

bcm	billion cubic meters
GW	Gigawatt
kWh	Kilowatt hours
Mtoe	Million tonnes of oil equivalent
Mt	Million tonnes
MW	Megawatt
TWh	Terawatt-hour

Abbreviations:

RES	Renewable Energy Sources
RET	Renewable Energy Technologies
SDGs	Sustainable Development Goals
EU	European Union
CC	Command-and-Control instruments
MB	Market-based instruments
IN	Information instruments
PAs	Policy aims
PTs	Policy targets
GDP	Growth Domestic Product
USD	U.S. dollar
AZR	Azerbaijan
KAZ	Kazakhstan
RUS	Russian Federation
GEO	Georgia
ARM	Armenia
UKR	Ukraine
MLD	Moldova
POL	Poland
IEA	International Energy Agency
EIA	Energy Information Administration
IRENA	International Renewable Energy Agency
REN21	Renewable Energy Policy Network for the 21st Century
UN	United Nations
WB	World Bank

1. Introduction

The important role of renewable energy sources (RES) in mitigating climate change, bolstering energy security, and bringing economic and social benefits has been proven (Edenhofer et al., 2011; Hache, 2018). Renewable energy also has a strong impact on, and synergy with, some of the UN's Sustainable Development Goals (SDGs) such as SDG 7 (affordable and clean energy), SDG 8 (decent work and economic growth), SDG 12 (responsible consumption and production), and SDG 13 (climate action). Countries can transform their energy systems to pursue the achievement of these SDGs by increasing their share of RES and carefully selecting the most appropriate energy sources to bolster their social and economic development, while also limiting harm to protecting the environment (Yuping et al., 2021; Murshed and Tanha, 2021). Currently, renewable energy accounts for 11.8% of total global energy consumption (electricity production, heating, and cooling, transport sector), representing an increase from 4.6% in 2000 (IRENA, 2019a; Oguzhan and Goktug, 2020). However, comprehensive support instruments aligned with some policy aims, clear plans for policy implementation, and policy evaluation is necessary to ensure widespread deployment, diffusion, promotion, and generation of renewable energy technologies (Pitelis et al., 2020; Shadrina, 2020). Pertinently, this calls for adequate government action to help to advance renewable energy technology at various levels along with regional trade integration (Murshed et al., 2021) and national trade liberalization policies (Murshed, 2021). The European Union (EU) directive on this subject laid out the goal of enhancing the proportion of renewables in electricity production to four-fifths by the middle of the 21st century (EC, 2020). The strategic goals underpinning this directive are to lower greenhouse gas emissions, to boost the safety of energy supply and technological advancement, as well as to create jobs and allow regions to develop (Mandley et al., 2020; Azhgaliyeva et al., 2020). Prominent policy implementation instruments for the promotion of renewable energy technologies are feed-in tariffs and, to a now almost negligible extent, tradable green certificate systems (Pablo-Romero et al., 2017). In addition, some EU Member States, in particular Poland, use tax incentives to encourage investment in renewable energy projects (Gnatowska and Moryń-Kucharczyk, 2019). There are also clear political aims to develop the renewable energy sector in parts of the EU's Eastern Neighborhood, namely in Russia and Kazakhstan, albeit with diverging rationales behind the policy goal to promote renewables. Meanwhile, Ukraine, Moldova, and Armenia all aim to minimize their dependence on Russian gas, forming resilient national energy policies and competitively-priced energy systems for customers (Sabishchenko et al., 2020). Elsewhere, Azerbaijan sees renewable energy as an opportunity to attract foreign direct investment (FDI) into the electricity and heating sector and grid infrastructure, which is outdated and in urgent need of modernization to provide accessible, secure, and reliable energy (Vidadili et al., 2017). Kazakhstan wishes to become a leader in renewable energy production and technology production in Central Asia, while also using renewables as an opportunity to reduce its coal consumption (Kerimray et al., 2017, 2018) and to enhance the country's environmental image in the international arena (Koch and Tynkkynen, 2021). In fact, Kazakhstan is very often noted as a resource-rich state suffering from environmental degradation due to its central role in traditional hydrocarbon fuel markets, and renewables are viewed as a chance of presenting the country in a better light (Karatayev et al., 2016). Meanwhile, Russia's main motives in this regard are to decentralize energy facilities in its more remote regions and to enhance agriculture (Makarov, 2018; Chebotareva et al., 2020), while also being wary of global renewable energy transformation, which it perceives as a threat to its national economy (Makarov, 2020). To achieve their policy aims with respect to renewable energy market growth, all of the covered countries have adopted three categories of instruments, namely command-and-control (CC), market-based (MB), and information (IN) instruments. However, there are no universally applied instruments when it comes to supporting renewable energy technologies. The most suitable instruments for one country may not be so appropriate for another. All of these countries are of course different in terms of their economic background, political stability, resource availability, and energy regime. The eight selected nations can be broken down into energy-poor (Ukraine, Georgia, Armenia, Moldova, and Poland) and energy-rich (Russia, Kazakhstan, and Azerbaijan). Furthermore, some of them are resource-transit countries (Ukraine, Georgia, and Azerbaijan) in which there are oil and gas pipelines connecting Russia to Ukraine and Europe, as well as from Azerbaijan to Georgia and Europe. In addition, according to global carbon emissions data, Russia is ranked 4th, Poland sits 20th, Kazakhstan lies 21st, and

Ukraine is 26th among 214 countries in total. By applying the policy cycle framework (Falcone et al., 2019), this paper examines what policy aims (PAs), policy targets (PTs), and instruments (command-and-control, market-based, and information instruments) for the promotion of renewable energy technologies (RET) are being adopted in the former Soviet bloc, how the renewable energy sectors are progressing, and what prospects there are for the future. The research into the former Soviet bloc's energy policy has almost exclusively concentrated on fossil fuels, nuclear energy, and substantial hydro-energy projects, while programs to develop renewable energy projects in the former Soviet bloc have been largely ignored to date.

2. Methodological framework

The analysis of why and how renewable energy technologies are being promoted, as well as determining the respective prospects, is based on the policy cycle framework, extended by authors in the relevant literature. The framework is commonly used in socio-technical systems including in the renewable energy sector (Pahle et al., 2016; García-Gusano et al., 2017; Falcone et al., 2019). It includes policy aims, policy implementation, and policy evaluation stages (MacLennan, 1980; Almeida and Báscolo, 2006). In the course of deciding its policy goals, a government picks out a specific issue and lists potential alternatives to address it. Inside a policy cycle framework, there is an implementation period in which action is taken, with governments putting policy into practice taking into consideration all aspects including population behaviors related to energy conservation and climate protection (Thaller et al., 2020). To be specific, implementation should ultimately end up with the pre-set policy goals being accomplished. Those engaged in implementation choose from an assortment of instruments to appropriately pursue these goals accordingly. These instruments are split into three types: command-and-control; market-based; and information and social. The first of these concerns legislative regulations and projects enacted by a government in order to popularize renewables in the field of energy production. Meanwhile, market-based tools include financial encouragements such as subsidies and grants, or sometimes exemptions from taxes or tariffs. The final type of policy instrument, namely information and social, have a bearing on how policies advance via the exchange of knowledge and interaction (Brudermann et al., 2019a,b). Elsewhere, policy assessment is a vital part of the policy cycle. Essentially, the policy instruments are reviewed with respect to how well they have accomplished the policy goals. If the instruments, or some of them, have not worked effectively, then the whole policy and corresponding tactics are extensively revised. In the course of policy assessment, data are yielded that may be able to aid the enhancement of the implementation process, and may also serve as lessons learned for future work to bear in mind. All phases of the policy cycle are interlinked and cannot be strictly separated. This paper focuses on policy aims (why), policy implementation (what and how), and policy evaluation (with what prospects) phases.

3. Energy and economics

Among all of the sample countries, Russia has the highest gross domestic product (GDP) (1.7 trillion USD), followed by Poland (595 billion USD), Kazakhstan (181 billion USD), Ukraine (153 billion USD), Azerbaijan (48 billion USD), while Georgia, Armenia, and Moldova have the lowest GDP (all ranging between 10–15 billion USD). At the beginning of the 1990s, the national economies of post-Soviet countries were paralyzed by a full-scale crisis, which affected GDP growth, total energy production,

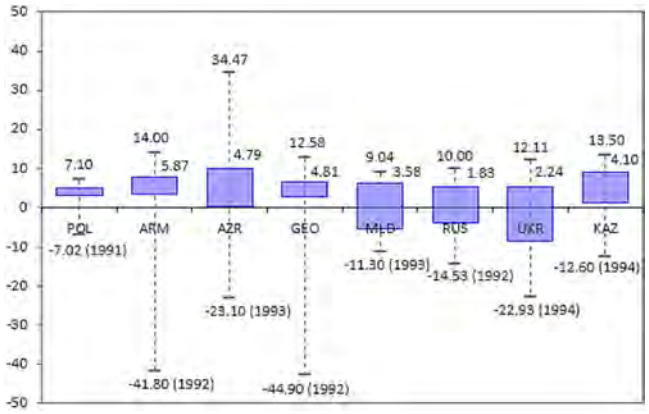

Fig. 1. GDP growth trends, 1991–2020 (%).

consumption, and electricity output (Fig. 1). Significant drops in GDP were observed in Georgia (−44.9%), Armenia (−41.8%), Azerbaijan (−23.1%), and Ukraine (−22.9). After the collapse of the Soviet Union, to overcome their economic difficulties, resource-rich countries pursued the development of their oil and gas industries, while resource-poor countries advanced their agriculture and service sectors. These particular trends were observed in previous research on energy abundance and industry differentiation between resource-rich and resource-poor countries (Gerlagh et al., 2015). The resource-poor countries have had trouble attracting investments into their agriculture and service sectors, while resource-rich countries, in the course of luring investment from abroad into their oil and gas sectors, have been at the mercy of international events (Spankulova et al., 2020). From 1991 to 2020, economic development patterns showed that resource-rich countries are fragile to changing prices of commodities in the world markets. Indeed, the lowering of oil prices globally leads to so-called Dutch disease whereby the discovery of fossil fuel materials transforms a country's economy and leaves it open to exploitation. Thereafter, when shocks hit, the same economy may be in a poorer state than before the discovery of resources (Azhgaliyeva, 2018). Such problems have been visible in numerous nations including Azerbaijan and Kazakhstan. In the former, crude oil and oil products contribute to four-fifths of its overall energy exports, with gas contributing the remainder. In the mid-2000s, when oil prices were relatively high, the Azerbaijani economy enjoyed substantial growth in terms of GDP, at times being a world leader in this indicator. Once oil prices dropped, however, the country suffered a significant dip in its GDP. Similar trends have been noted in Kazakhstan, and indeed Russia.

4. Energy production

From 1991 to 2020, total primary energy production increased in the sampled resource-rich countries, namely Azerbaijan, Russia, and Kazakhstan. From 1991 to 2020, total primary energy production in Azerbaijan increased by 14.6% per annum. In 1991, the primary energy production of Azerbaijan was 18.9 Mtoe, which subsequently peaked at 65.5 Mtoe in 2010 (Fig. 2). Its current level of energy production is 55.3 Mtoe. Azerbaijan is a major crude oil producer (37.5 Mtoe), 30.8 Mtoe of which goes to international markets and it makes the country a major oil exporter (IEA, 2020). The country is also a significant producer of natural gas (24.5 bcm), 11 bcm of which is exported (WB, 2020). Oil and gas account for more than 90% of Azerbaijan's exports (BP, 2020). Given the resource availability it has recently enjoyed, Azerbaijan has reduced its energy import dependency from 70.5%

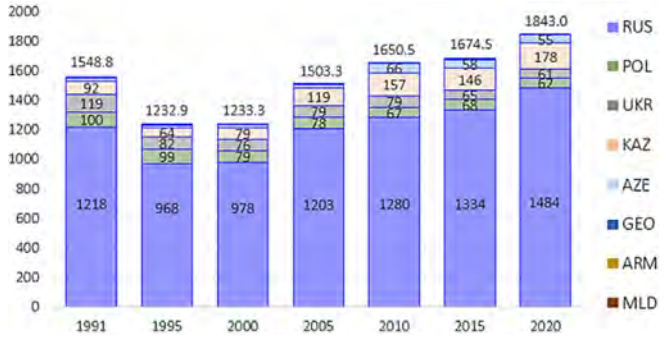

Fig. 2. Total energy production, 1991–2020 (Mtoe).

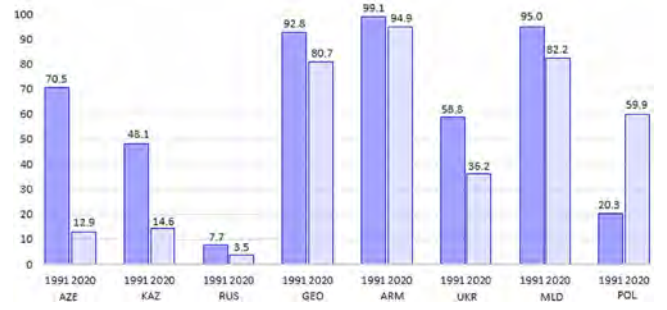

Fig. 3. Dependence on energy imports (%).

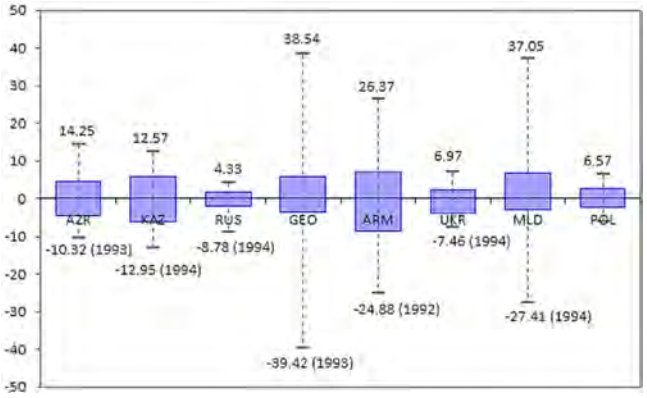

Fig. 4. Total primary energy consumption trends, 1991–2020 (%).

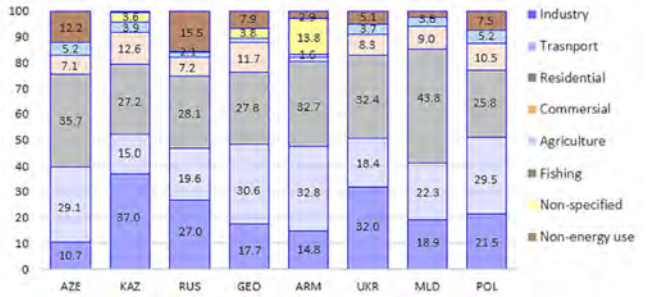

Fig. 5. Energy consumption by sectors (%).

in 1991 to 12.9% in 2020 (Fig. 4). Meanwhile, Kazakhstan's current total energy production is 177.5 Mtoe, which is almost double the level of 1991 (91.8 Mtoe). Kazakhstan is globally prominent when it comes to fossil fuel production, and in 2020 the country was listed 9th in the world for coal production (IEA, 2020) – 108 Mt of coal mined). Meanwhile, in the same year, it was listed 17th globally in terms of crude oil production (92 Mt of oil extracted) and 24th for natural gas (39 bcm extracted) (BP, 2020). Elsewhere, Russia plays a key role in the world's energy framework. Boasting 3% of global GDP and 2% of the world's population, Russia is responsible for one-fifth of the world's primary energy production. Between 1995 and 2020, the country's overall energy production soared from 967.6 Mtoe to 1484.1 Mtoe. At the same time, in terms of crude oil production, Russia is the world leader, producing an average of 11.2 million barrels daily, while it produces the second-most dry natural gas of any country in the world (IEA, 2020). In addition, Russia's coal production is also substantial. This allows Russia to keeps a low level of energy import dependency with just 3.5% of its energy being imported in 2020.

Among the resource-poor countries, the domestic energy production of Georgia is 1.2 Mtoe, consisting mainly of hydropower and fuelwood, with small amounts of coal, oil, and gas production. Georgia imported 80.7% of its energy consumption in 2020. Armenia and Moldova are both landlocked countries without oil and hydrocarbon reserves and limited energy production. This burdens both Armenia and Moldova with a high level of energy dependency, with the former importing 94.9% of its energy and Moldova importing 82.2% of its energy in 2020, both almost exclusively from Russia (EIA, 2020). Moldova imports 100% of its gas from Russia and purchases electricity from Ukraine and Romania as well. Moreover, some of its electricity is produced by Dubasari HPP, which belongs to the Russian company "Itner RAO". In resource-rich countries, there is often a strong political and social consensus favoring state intervention when it comes to the exploitation of petroleum resources. State involvement in an economy can create economic and political dependence on exports for resource-rich countries, while for their resource-poor counterparts import dependency prevails (Karl, 1997). With this in mind, we can observe international tensions between states and integrational organizations. Thus, Armenia and Moldova are vulnerable to risks related to energy supply disruption. Even though Ukraine produces all types of fossil fuel, its production is not at a level that satisfies the national need (14.4 Mtoe of coal, 16.5 Mtoe of natural gas, and 2.3 Mtoe of crude oil). Poland's total primary energy production decreased to 62.4 Mtoe in 2020, from 99.8 Mtoe in 1991, while its energy import dependency rose from 20.3% in 1991 to 59.9% in 2020 (Fig. 3).

5. Energy consumption

Total energy consumption increased steadily in all sample countries by an average of 2%–3% annually during 1991–2020, peaking at the beginning of the 2000s. Earlier, a significant drop in energy consumption was observed at the beginning of the 1990s, specifically between 1992 and 1994 because of the economic crisis caused by the collapse of the Soviet Union (Fig. 4). The industrial sector represents the main ultimate energy consumer in Kazakhstan, Russia, and Ukraine, with it being responsible for over 30% of final consumption (Fig. 5). Meanwhile, in Azerbaijan, Georgia, Armenia, and Poland it is transport (25%–30% of final consumption), ahead of residential property and industry. In Moldova, the residential property sector makes up the greatest share of final energy consumption (43.8%), with industry taking up a relatively low 18.9% (Fig. 6). Energy consumption based on fossil fuels remains dominant in all sample countries, while the contribution of renewable energy resources is negligible in all countries except Moldova, which uses biomass mainly in its heating sector (Fig. 6). Azerbaijan's current energy consumption is 9.4 Mtoe. Oil and gas account for 64.7% and 32.8% of total final

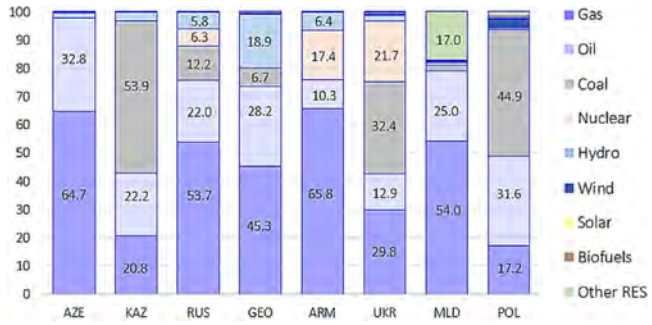

Fig. 6. Total energy consumption by source (%).

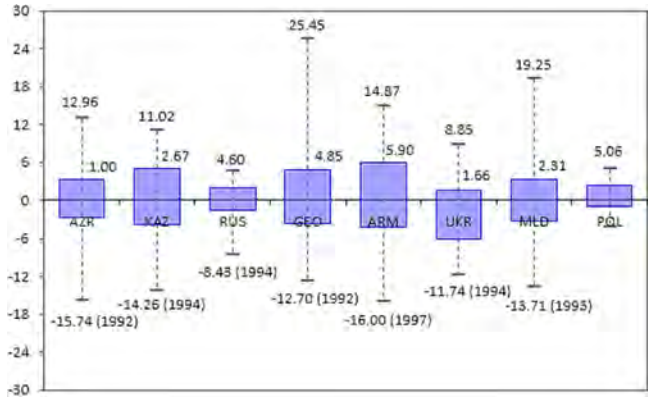

Fig. 7. Electricity production trends, 1991–2020 (%).

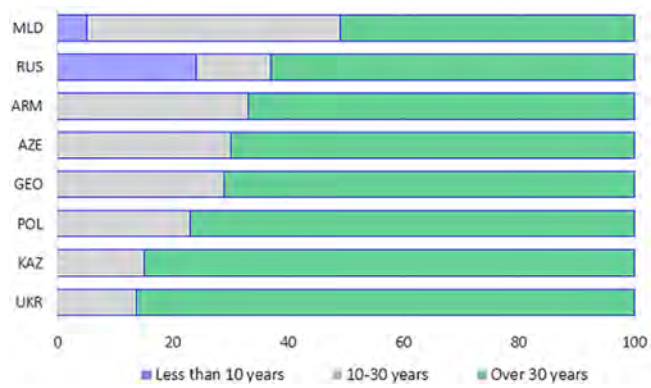

Fig. 8. Age profile of existing power capacity, %.

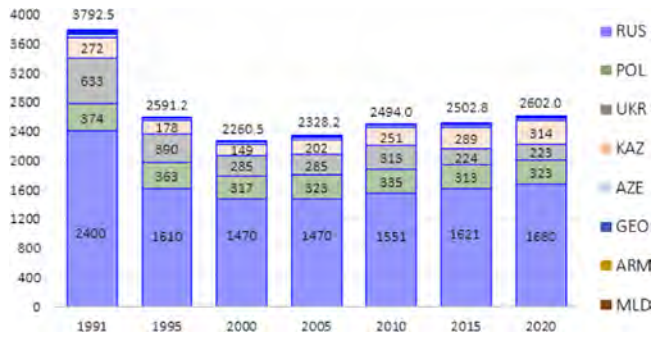

Fig. 9. Annual carbon dioxide emissions (Mt).

consumption (IRENA, 2019b). Kazakhstan's total energy production also covers more than twice its current energy consumption level, which is 76 Mtoe. In terms of Kazakhstan's energy breakdown, coal makes up 53%, ahead of oil (20.8%) and natural gas (22.2%) (EIA, 2020). Meanwhile, Russia uses 850 Mtoe of energy, over half of which is natural gas (53.7%), followed by oil (22%) and coal (12.2%) (WB, 2020). Elsewhere, Georgia uses 4.8 Mtoe, with oil (45.3%) and natural gas (28.2%) representing the country's most prominent sources of energy. Armenia consumes 3.1 Mtoe and, furthermore, energy demand continues to grow and is forecasted to grow further, with existing supply capacities insufficient to meet the growing demand (Vardanyan, 2009). In Ukraine's primary energy consumption, coal represents the greatest share with 29.8%, ahead of natural gas (32.4%) and nuclear (21.7%) (IEA, 2020), followed by oil and other liquid fuels (15%). Total primary energy consumption in Moldova at the beginning of the 1990s was half less compared to the 2000s (Fig. 4). The main fossil fuel in this country is gas. As for Poland, the total primary energy consumption has increase by an average of 2.7% annually over the covered period, due to economic and population growth. Currently, Poland consumes approximately 75.8 Mtoe. In 2020, coal was responsible for approximately 44.9% of its total primary energy consumption, with oil and natural gas contributing 31.6% and 17.2%, respectively. As for renewable energy resources, their consumption increased from 0.4% to 3.2% between 2000 and 2020, with a significant boost in wind power generation.

6. Electricity and infrastructure

Total electricity output also increased in all sample countries over the covered period. As was the case for total energy consumption, a significant drop in electricity production was observed at the beginning of the 1990s, particularly between 1992 and 1994 as a result of the economic crisis (Fig. 7). Since then, electricity consumption has increased steadily in all sample countries at an average rate of 1.5–2.5% annually. However, in all sample countries, most of the power plant infrastructure, including generation, transmission, and distribution facilities, is becoming outdated (Fig. 8). The existing power capacities and grid infrastructure were mainly built during Soviet/communist era. Indeed, 75%–85% of operating fossil and nuclear capacities in Ukraine, Kazakhstan, and Poland are over 30 years old, while the corresponding figure is 65%–70% for Georgia, Armenia, and Azerbaijan. The lowest percentage of aging infrastructure is found in Russia and Moldova. On average, a power plant has an operating lifespan of around 40 years for coal, 35 for gas, and 34 for oil. Meanwhile, the expected lifespan for a nuclear facility is 40 years, with the average age of operational nuclear plants standing at 30 years (IEA, 2020). As the infrastructure gets older, the expense of running them and corresponding upkeep increases, while it becomes less reliable too, with a damaging impact on the electricity market more broadly.

7. Environment, renewables and investments

Following the break-up of the USSR, carbon emissions dropped markedly during the economic crisis that struck in the first half of the 1990s. Since then, carbon emissions have increased modestly, but the current level still does not exceed the level of 1991 (Fig. 9). All sample countries have taken some part in the international climate change mitigation efforts and have participated in the UN Framework Convention on Climate Change, the Kyoto Protocol, and, more recently, have joined the Paris Agreement. As part of their commitment to reducing carbon emissions, the sample countries have looked to develop their renewable energy sectors, and these nations have substantial possibilities

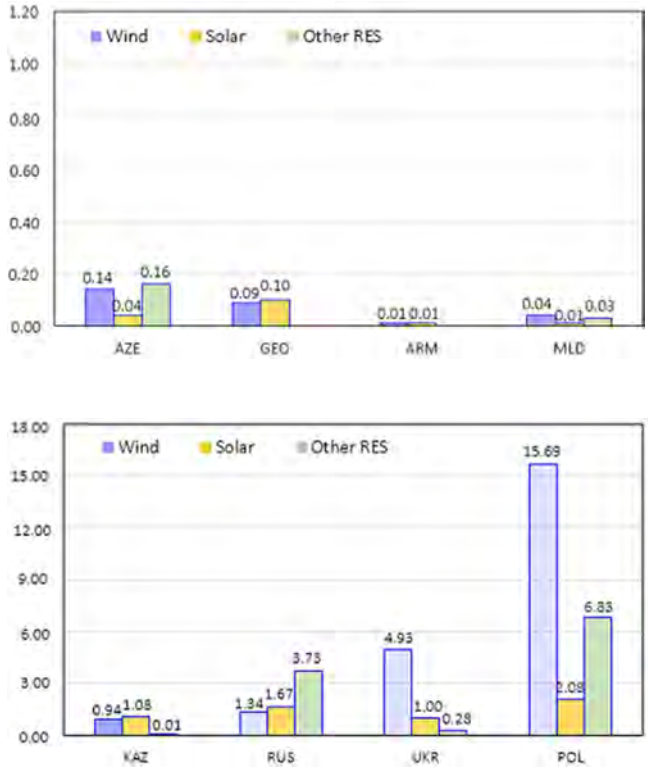

Fig. 10. Renewables in electricity mix (TWh).

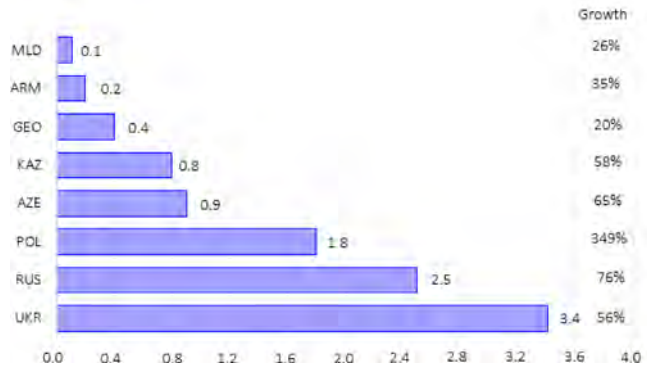

Fig. 11. Renewable energy capacity investment, USD billion.

when it comes to renewables. Azerbaijan boasts superb solar and wind resources and has notable potential with regard to biomass, geothermal, and hydro as well (Nuriyev et al., 2019; IRENA, 2019a). Despite this, the country's use of renewable energy stands at only 2% of its overall primary energy supply and makes up just 8% of its electricity supply (KNOEMA, 2020; Aydin, 2019). Meanwhile, Azerbaijan has some plans to privatize its energy sector and to encourage private investment (Mukhtarov et al., 2020). Elsewhere, Kazakhstan's potential in terms of renewables is vast, especially in wind and hydro. Kazakhstan is capable of producing 100% of its energy demand through just wind power (Jianzhong et al., 2018). But, in this country renewables currently make up less than a percent of its power facilities (Fig. 10). Within Kazakhstan's renewable energy sector, small hydropower projects dominate (REN21, 2020). In the case of Russia, the overall capacity of its unified energy system is 243.2 GW, of which just 0.03% is represented by wind power (11 MW) and solar power (60 MW). The country's potential with regard to the latter two types of energy is massive. For wind power, its potential is estimated at 80,000 TWh annually, of which 6,218 TWh is economically achievable (IRENA, 2017). In terms of solar power, Russia's potential stands at 2,213 TWh annually, of which 101 TWh is economically achievable (Pristupa and Mol, 2015). Worldwide, Russia stands fifth in terms of hydroelectric production, with this type of energy making up 16% of its overall electricity production (KNOEMA, 2020). Aside from expansive hydropower, the contribution of other renewables is minimal (0.05%) (OWD, 2020). The country invested 2.3 billion USD in its renewable energy capacity in 2019, an increase of 76% compared to the previous year (Fig. 11) (WB, 2020). Elsewhere, Georgia has potential when it comes to the utilization of renewable energy. Currently, 1.1% of its installed capacity derives from renewable energy sources (IRENA, 2018). Small hydropower facilities represent the greatest source of renewable energy in the country where there is also potential for bioenergy development, albeit the current contribution of bioenergy to the national energy profile is less than 0.1% (REN21, 2020). Nearby, Armenia boasts notable renewable energy resources, but at present renewables barely feature in its energy composition. Potential for around 740 MW from small hydropower, wind, and geothermal energy resources has already been recorded, which would potentially amount to a quarter of the country's current capacity (KNOEMA, 2020). Meanwhile, for Ukraine, the overall technically feasible energy potential of renewables is 98 Mtoe or 548.5 billion kWh per year (without large hydro-energy), more than doubling its current rates of energy generation (Kharlamova et al., 2016; IRENA, 2018). Within this potential mix, bioenergy makes up 31 Mtoe (178 billion kWh), while energy stored in the environment represents 18 Mtoe (146.3 billion kWh), geothermal energy amounts to 12.0 Mtoe (97.6 billion kWh), wind energy is measured at 28 Mtoe (79.8 billion kWh), solar energy equals 6.0 Mtoe (38.2 billion kWh), and small hydro-energy represents 3.0 Mtoe (8.6 billion kWh). However, presently, usage is still limited, standing at around 2% by the end of 2020 (IRENA, 2018). Currently, Moldova's renewable energy makes up 17% of its energy mix, most of which stems from biomass such as agricultural waste, firewood, and wood-processing waste products (IRENA, 2019b). The nation's renewables potential (discounting sources with low thermal prospects) is estimated at 2.7 Mtoe (REN21, 2020). For Poland, the proportion of electricity amassed from renewables rose markedly between 1995 and 2020 (from 0.7% to 5.6%) (OWD, 2020). Currently, wind is the major renewable source of electricity production, contributing 3.2% of total electricity production (KNOEMA, 2020). Biomass, biogas, and hydropower in small-scale hydropower plants also play important roles in the country's electricity production. The current level of investment in renewable energy systems is about 1.8 billion USD (Fig. 11).

8. Targets and policies for RES

Azerbaijan has put together a national plan for alternative and renewable energy, and this is in the course of being implemented. Previously, the country failed to hit its targets regarding climate change and energy consumption. Specifically, compared to 1990 rates, it aimed to lower its greenhouse gas emissions by one-fifth, it sought to increase its proportion of renewables in the energy mix to 20%, and to boost energy efficiency by the same percentage within 30 years. Recently, the Azerbaijani government pledged to lower its greenhouse gas emissions by 35%, while it is contemplating a ten-year goal of upping its renewables share in power production to 30% (UN, 2019). Pertinently, for various types of renewable energy, feed-in tariffs have been introduced. Moreover, a national program has been launched on electrical and

heating power plants, outlining that renewables facilities could receive state investment in solar and wind (up to 100 kW) and small hydropower (up to 10 MW) (Vidadili et al., 2017). Facilities using a minimum of 80% of biomass (not including firewood) have been given the right of unlimited purchase. Moreover, the Azerbaijani government also recently created the National Agency on Alternative and Renewable Energy Sources, helping the country to build a pilot small hydropower plant, as well as assisting in the establishment of a law on renewable energy, in assessing the actual economics of renewables in Azerbaijan, and in the preparation of pilot renewable energy projects covering biomass, wind, and solar.

Kazakhstan's government has been backing renewables since 2000 when it launched the Law on Supporting the Use of Renewable Energy Sources. This legislation enhances technology-related feed-in tariffs for renewables technology, including biomass, solar, wind, geothermal, and hydro for a decade-and-a-half (Abdildin et al., 2021). Furthermore, a roadmap to build-up alternative and renewable energy in Kazakhstan for the first half of the 2020s was also established (Mouraviev, 2021a). The country's goals regarding climate change and energy are ambitious, with the aim being to increase renewables to the point that they make up half of the energy mix by 2050 (Karatayev et al., 2016). Through power purchase deals agreed by regional grid operators and renewables facilities, the security of investments in this area is heightened. The facilities operator is not obliged to pay for transmission services, and it gains free access to the power network. In addition, projects revolving around renewables are given priority when it comes to issuing land plots, and these are not subjected to customs duties for necessary imports. Moreover, the Law on Investment permits renewables sites to obtain national grants of up to as much as 30% of the project expenses connected with the given land plots, buildings, machinery, and equipment (Boute, 2020). International investors can also apply for tax deductions such as for land and property. Moreover, maps of proposed wind, solar, and bioenergy projects are accessible, and these give interested investors extensive data with regard to wind resources.

Elsewhere, Russia has laid out strategic aims for renewables. Specifically, the country had intended to have renewables (other than large hydro) contribute 4.5% of its overall power production by 2020. Indeed, by 2010, Russia had hoped to achieve 1.5% in this respect, and to reach a 2.5% target by 2015 (IRENA, 2018). The latter two aims were not accomplished though, and the deadline was pushed back by four years (REN21, 2020). As Russia presently produces not even 0.05% of its electricity from renewable energy (other than large hydro), this goal still seems unlikely to be achieved. To accomplish these goals, Russia has brought in renewable energy support programs such as premium-based feed-in tariffs as well as a capacity-related support project to assist with solar, wind, and small hydro in the overall market (Proskuryakova and Ermolenko, 2019; Chebotareva et al., 2020). Russia's capacity-based renewables framework includes economic motivations to produce power at the built renewables facilities thereby lowering the threat of facilities going unused (Namsaraev et al., 2018). Furthermore, a support program for renewable energy in the retail market has been brought in. Pertinently, those operating the Russian grid must buy energy from verified facilities at legal prices, as long as the purchase does not exceed 5% of estimated transmission power losses (Ratner and Nizhegorodtsev, 2017). This is not restricted to solar, wind, and small hydro technology, but also encompasses the retail electricity market, entailing non-grid sites from the unified energy framework.

In Georgia, a legal and regulatory system regarding renewables has been growing since 1998 (Samkharadze, 2019). In particular, the country has a law in place containing stipulations to arrange renewables goals and to gauge the progress made (Chowaniak et al., 2021). This law also outlines a system for the bringing in of renewable energy support methods. Even though such mechanisms are being developed, it is not yet known if bioenergy technology will be covered. Meanwhile, Georgia is also putting together the National Energy and Climate Plan for 2021–2030, looking ahead to 2050 guarantee alignment with long-term EU goals (Chomakhidze et al., 2017). This strategy will set out a blueprint for renewables targets for 2030, with the corresponding support measures also presented (Chomakhidze et al., 2018). As well as the project-specific feed-in tariffs for hydropower plants up to 100 MW, developers of hydropower plants up to 10 MW are also granted more benefits (REN21, 2020). Small hydropower plants are not required to sell their electricity to the national grid, but rather directly to consumers at bilaterally negotiated tariffs. Small hydropower plant developers are allowed to export their electricity without an export license, except for the three winter months (December, January, and February), when the Government of Georgia offers a power purchase guarantee to ensure domestic energy supply (Zhakupova et al., 2021). In addition, distribution companies are obliged to provide free grid connections. Meanwhile, to reduce potential investors' information costs, the Ministry of Energy has published a manual for small hydropower developers, and a list of possible small hydropower plant grounds open for investment with detailed pre-feasibility studies, and currently the support for small hydropower plants is very investor-friendly.

Armenia's Strategic Development Program for the Hydro Energy Sector forecasts that, by 2025, 30% of Armenia's energy demand will be met by renewable energy (REN21, 2020). In addition, the country's Renewable Energy Roadmap defined targets for the installed capacity of renewable energy sources to meet the forecasted electricity demand. The specific targets were 197 MW installed renewable energy capacity by the end of 2013, 282 MW by 2015, and 545 MW by 2020 (IRENA, 2018). Elsewhere, the Law on Energy regulates interactions between stakeholders in the electricity market, for example the 15-year electricity purchase guarantee by grid operators for electricity produced from renewable sources (Kosowska et al., 2018). The Law on Energy Saving and Renewable Energy regulate specific renewable energy issues. It also gives regulatory power to the Public Service Regulatory Commission. The Law on Licensing requires licenses for power generators, and these licenses can be obtained from the Public Service Regulatory Commission. Foreign investment companies are subject to the same tax regimes as Armenian companies, while specific tax exemptions and privileges may apply if the foreign investment exceeds 1.2 million USD (Saiymova et al., 2020). The Law on Energy of Armenia assigns responsibility to the Public Service Regulatory Commission to determine tariffs each year for both newly-commissioned and existing generators, including technologic specific feed-in tariffs for wind, biomass, and small hydropower plant producers (Babayan et al., 2014). The tariffs ensure guaranteed purchase of produced electricity for 15 years from the Commission. They are determined by the Public Service Regulatory Commission to ensure that all current and recurring capital costs are covered and a sufficient rate of return is provided.

In Ukraine, the Ministry of the Energy and Coal Industry determined that, by the end of the 2020s, a total of 19% of overall energy consumption and one-tenth of current power capacity ought to emanate from renewable and alternative sources (IRENA, 2018). The country's energy policy until 2030 envisages a broad project regarding energy efficiency, calling for the lowering of energy consumption by 30%–35% by the end of this decade (Sabishchenko et al., 2020). Meanwhile, Ukraine has made a commitment to incorporate the EU Climate and Energy Directive (and

amendments) to Article 20 of the Energy Community Treaty. The country's proportion of energy taken from renewables was marked at 11% for 2020 (Nykyruy et al., 2020), which has not been met. On top of the feed-in tariff, numerous tax breaks for renewables initiatives (Kucher and Prokopchuk, 2018). There is also a VAT exemption on imports earmarked for the building of renewable energy facilities. Moreover, taxes on land used for an installed renewable generation have been cut by 25%, while equipment using renewable sources is granted a VAT exemption too. The safety of long-term investments is ensured by feed-in tariff payments. Furthermore, the green tariff, which supports various kinds of renewable energy, is altered monthly in accordance with the exchange rate, albeit with a set minimum amount. Following a change to the tariff scheme, Local Content Requirements were brought in. With respect to power plants, the tariff only applies where the overall construction costs are composed of 30% Ukrainian materials, fixed assets, and services (Kurbatova and Khlyap, 2015). This has subsequently risen to 50% for power plants. Moreover, solar plants can only be eligible for the tariff if the installed modules include 30%–50% of Ukrainian materials in their production expenses.

Looking at Moldova, a shortage of resources and heavy energy demand have triggered the prioritization of renewables (Karakosta et al., 2011). In order to enhance renewables in the country, the Law on Renewable Energy Sources was passed. This law stipulates that electricity gleaned from renewables is largely advocated via a feed-in tariff. Specifically, a pair of varying processes are to be applied to choose which plants are going to take advantage of the tariff, depending on the plant's size. Renewables developers are given priority and free access to the grid. Moreover, the National Renewable Energy Action Plan has also been enacted, outlining strategies and activities in pursuit of renewable energy growth in the country. Furthermore, the Energy Efficiency Fund was established to give renewables developers financial incentives and technical assistance. In Moldova, the investment environment boasts numerous incentives, including favorable treatment and tax breaks for external investors and technology export, in addition to decade-long immunity to legislative amendments.

The most important objective of Poland's energy policy is to reduce the proportion of electricity produced from coal from 70% to no more than 56% by 2030, while significantly increasing the share of renewables to at least 32% by the same year. The primary means of making this goal a reality is expanding biomass farms, solar and offshore wind farms, and hydropower as the sources with the best prospects for application in Poland given the present energy rates and the conditions needing to be met for state aid to be granted. Developing renewables ought to also assist in lowering its greenhouse gas emissions by 30% by 2030 in comparison to 1990 rates. To back the renewables industry, Poland introduced the Law on Energy which states that companies need to buy energy from renewable sources, and that renewable producers are given favorable treatment when accessing the grid. Moreover, electricity produced from renewable sources is granted an excise tax exemption, while the fee for connecting to the grid for smaller renewables facilities (less than 5 MW) has been halved. These facilities are also given an exemption from annual license fees. Funding of renewables can be co-financed by the National Fund for Environmental Protection and Water Management and funding is also pursued via the Polish Investment & Trade Agency.

9. Summary and discussion

Renewables growth is not merely a legal matter; it is also an issue of political and economic importance. Accordingly, to the east of Poland, both Russia and Kazakhstan have set out a range of national policies, vital to the growth and usage of renewable energy. In Poland's Renewable Energy Development Plan, the most important objective of national energy policy is to reduce the proportion of electricity produced from coal from 70% to no more than 56% by 2030, while significantly increasing the share of renewables to at least 32% by the same year. Russia has set a national goal for its renewable energy sector of 4.5% by 2024. Elsewhere, a declaration was made by Ukraine that 19% of its overall energy consumption and one-tenth of its current electricity capacity ought to emanate from renewable and alternatives sources by the end of this decade. Compared with other sample countries, Kazakhstan and Azerbaijan have set the most ambitious targets to develop their renewable energy sectors. Kazakhstan's national plan aims for a 50% proportion of renewable energy in its electricity production structure by 2050. In Azerbaijan, there are plans afoot to set a goal of reaching 30% renewables in its energy mix by the end of the 2020s.

At the end of this review, policy aims, policy implementation, and policy evaluation with respect to the promotion of renewable energy technologies in the countries of the former Soviet bloc are summarized in Table 1 and Fig. 12. Some of the policy aims such as accessible, secure, and reliable energy, competitively-priced energy, import independence reduction, as well as regional and global effectiveness are indicated to some extent in all sample countries. All of the sample countries include carbon emissions reduction, environmental protection, clean and sustainable energy, and other issues related to energy security in one way or another in their policy aims. Furthermore, all countries are trying to plan their energy futures up to 2020, 2035, or to 2050. To meet their policy aims, all sample countries have included a wide range of instruments in their national support schemes, which can be implemented in order to drive renewable energy market growth. Command-and-control instruments are key policy instruments (Fig. 13), and are established by a number of regulations and pieces of legislation such as laws on renewable energy development, guaranteed purchase by grid operators, and guaranteed grid interconnection. Market-based instruments include feed-in tariffs and tax incentives for encouraging renewables projects. As for information and social instruments, for public and private investment attraction, some countries have established investor's guides to renewable energy projects containing estimations of wind, solar, biomass, and mini-hydro energy potentials. These also include a national action plan on climate change, and a national roadmap for renewable energy projects. The need for comprehensive renewables policy observed in each of the covered countries, which may create potential for international cooperation and the transfer of know-how and new technology.

As shown in Poland's energy transition case, a clear and stable policy framework may result in less risk and, thus, lower costs for renewable energy projects' development. In this context, the establishment of clear national law on renewable energy development is considered the first critical step towards low-carbon energy development. Every one of the covered nations but Russia has adopted the needed legislative regulations regarding renewables. Moreover, evidence shows that such a law has had a positive effect on wind power in Poland. Indeed, the relevant law there deals in detail with numerous parts of renewable energy across several chapters. In addition, some provinces can also enact localized legislation regarding renewables, taking into account the given territory's energy and economic circumstances. In order to pass renewable energy legislation, government ministries and local governments put together department and government rules and draft further regulatory documentation. Compared to Poland, it can be seen that the EU's Eastern Neighborhood and

Table 1
Renewable-energy-related policy aims (PAs), policy targets (PTs), and instruments (CC, MB, IN).

Policy aims, targets, instruments	Countries							
	AZR	KAZ	RUS	GEO	ARM	UKR	MLD	POL
PA: Accessible, secure, and reliable energy	●			●	●	●	●	●
PA: Competitively-priced energy					●	●		●
PA: Resilience of the country's energy policy						●		
PA: Import independence reduction					●	●	●	●
PA: Energy-based economic growth	●	●	●					
PA: Reinforcement of external dimension of energy policy			●			●		
PA: Regional and global effectiveness		●	●					●
PA: Export of renewable energy			●					●
PA: Enhancement of gas supply systems	●	●	●			●		
PA: Advanced utilization of fossil fuels			●					
PT: Renewable energy increase	●	●	●	●	●	●	●	●
PT: Industrial improvement in energy efficiency	●	●	●			●		●
PT: Grid management and efficiency		●	●					●
PT: Climate change target	●	●	●	●	●	●	●	●
PT: Sufficient energy investments			●				●	●
PT: Increase nuclear power in electricity generation		●			●	●		
PT: New green jobs creation			●				●	●
CC: Guaranteed grid interconnection		●				●	●	●
CC: Guaranteed purchase by grid operators	●	●	●	●	●			●
CC: Law on renewable energy development	●	●		●	●	●	●	●
CC: Renewable capacity-based support			●					
CC: Carbon emissions trading scheme		●	●					
CC: Local content requirements						●		
MB: Feed-in tariffs as policy instrument	●	●	●	●	●	●	●	●
MB: Feed-in tariffs indexation for renewable projects		●						
MB: Renewable energy tendering scheme (auctions)		●				●	●	●
MB: Public investments in renewable projects	●	●					●	
MB: Green loans for renewable energy projects	●			●			●	
MB: Tax incentives for renewable projects						●	●	●
MB: Renewable reserve fund		●						●
MB: Energy start-up grants						●		
MB: Lower tax rates for technology imports						●	●	
IN: Public environmental protection awareness campaign						●	●	●
IN: Awareness of renewables and benefits campaign						●		●
IN: Wind energy potential atlas	●	●	●	●	●	●	●	●
IN: Solar energy potential atlas	●	●	●	●	●	●	●	●
IN: Biomass energy potential atlas		●						●
IN: Mini-hydro energy potential estimation				●				●
IN: National renewable energy agency	●	●						
IN: National action plan on climate change	●	●	●	●	●	●		●
IN: National roadmap for renewable energy projects		●		●	●		●	●
IN: Investor's guide to renewable energy projects		●						
IN: Professional training and qualification	●	●						

Kazakhstan's renewable energy legal framework have made great progress, however, as noted before, the current legal systems in these countries still do not sufficiently meet practical needs, with current law and procedures unclear. For example, there is a lack of clarity as to the process of how to acquire or access land for renewable energy projects. More comprehensive laws and regulations will be developed in the future, including lessons learned from national conditions and experience, as well as from EU Member States.

In addition to comprehensive law, it was recognized internationally that applying feed-in tariffs is the most effective policy instruments to encourage the rapid and sustained deployment of renewable energy. Currently, different feed-in tariff design models for market-based instruments have been a major instrument in the promotion of renewable energy technologies in Poland, the EU's Eastern Neighborhood, Russia, and Kazakhstan (Fig. 14). Every nation provides a guarantee for its feed-in tariffs and the majority of such tariffs are connected to supply contracts performed over the course of between a decade-and-a-half to two decades. Moreover, tenders form a pertinent piece of renewables activities in Poland, Ukraine, Moldova, and Kazakhstan. In tenders, governments and relevant bodies call for bids to supply electricity through particular technology, the aim of which is to gain energy provision at a reasonable rate and to boost the development of the desired technology. The procedure entails bids being lodged by various parties after a set capacity for renewables in a national electricity network is set. Bids are determined by the given capacity, desired technology, and geographical location, with various criteria (qualitative and quantitative), applied to decide the winning bid. However, there are certain risk components here, such as national currency fluctuation, generation cost-based

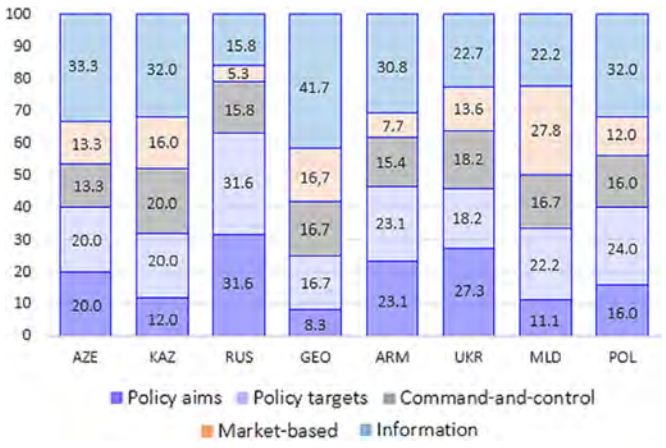

Fig. 12. Policy aims, targets and instruments (%).

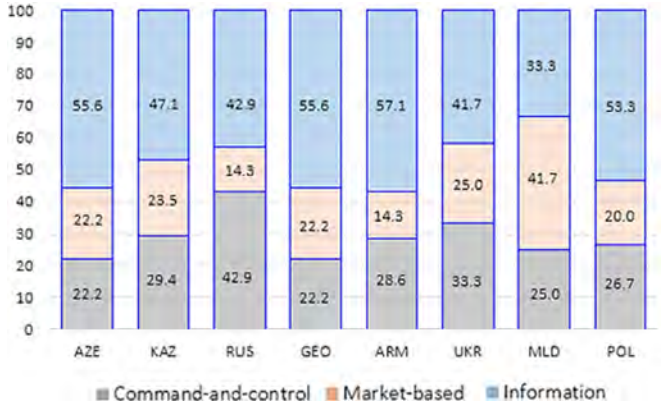

Fig. 13. Policy instruments (%).

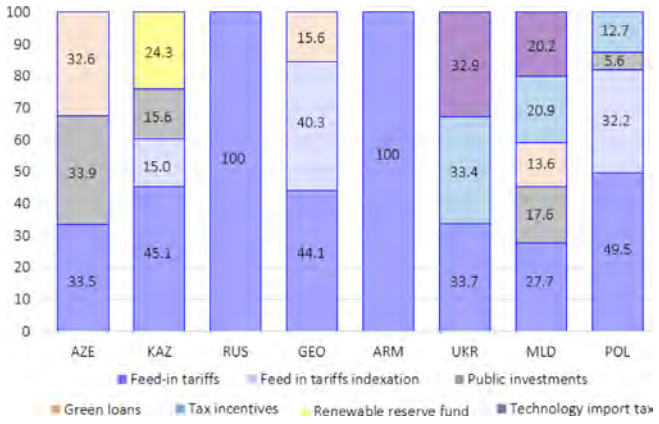

Fig. 14. Market-based instruments (%).

rates, degree of investment security, and supply chains. Therefore, the feed-in tariff models should be revised and re-structured.

Moreover, it is necessary to design short-, medium-, and long-term renewable reserve funds and other types of emergency mechanism in order to reduce the overall financial risk of investors. In fact, global crises have an impact on renewable energy's progress. The COVID-19 pandemic has impacted upon supply chains of renewable energy technologies and the attractiveness of public and private investments. As a result, new renewable energy projects have been postponed in all of the sample countries, partly because the renewable energy sectors in Poland, the EU's Eastern Neighborhood, and Kazakhstan rely heavily on technology imports from China. In 2019, Kazakhstan imported 65% of its solar modules and their elements from China, while for Russia this figure was 71%, and for Azerbaijan it was 85%. The COVID-19 pandemic has seriously affected construction in renewables in Kazakhstan, with the number of new facilities in 2020 dropping by 30% compared to the previous year. In contrast, tendering rose markedly in 2020 compared to the previous year. Moreover, the Kazakh government has established a renewables reserve to boost funding into renewable energy facilities, and to safeguard the financial wellbeing of national power figures, marking a vital step toward the ongoing progress of renewables in the country. Meanwhile, in Poland, plans have been made to accelerate renewable energy's progress, partly to offset the pandemic-induced crisis. In June 2020, the Polish authorities stated that the pandemic had forced a reassessment of priorities, with clean energy now being prioritized. This has since been backed up by planned tenders for wind power facilities as well as a declaration that an industrial policy would be unveiled for solar power. Moreover, Poland has joined the European Green Deal recovery program, which is founded on steps put forward by the European Commission. As for Russia, support for the renewable energy sector was not the State's focus during the COVID-19 pandemic, however the country now aims to increase its overall funding volume in the post-COVID-19 period. Elsewhere, Ukraine, Armenia, and Moldova have experienced a slowdown in renewable energy installations in 2020 due to the COVID-19 pandemic.

Finally, real-based practical guidelines for national and international investors are needed to provide a list of issues and questions to consider when enhancing investment in renewable energy development. Based on the international experience of developed countries, the guidelines provide tools to help local and international renewable energy project developers to determine the overall feasibility of siting renewable energy production and some key considerations for integrating renewable energy development during all phases. Kazakhstan, among all former Soviet bloc countries, was the first country to publish an investor's handbook regarding renewables projects, with financial assistance from USAID's Power the Future Regional Program. The handbook includes simple-to-follow advice for those considering investment in renewables in Kazakhstan, and contains information pertaining to national backing for the growth of renewables efforts and rules for tenders, in addition to an overview of the primary regulations covering all aspects of renewable energy projects. However, the direct use of renewable energy to provide energy services, such as heating and cooling, are not specifically covered in the investor's handbook regarding renewables projects in Kazakhstan.

In general, it has been observed that there are economic, social, geographic, and political factors leading to differences in the effectiveness and efficiency of various promotion instruments for renewables in Poland, the EU's Eastern Neighborhood, and Kazakhstan. In some countries, the structure of the economy, its priorities, and resource availability determine the setting of different barriers regarding renewable energy development (Mouraviev, 2021b,c). Compared to other sample countries, Ukraine, Kazakhstan, and Poland have made great improvements in terms of policy aims, targets, and instruments. All three countries have the most ambitious renewable energy targets compared to other sample countries and the government guarantees to buy electricity from renewables. However, for Kazakhstan and other energy-rich countries (Russia and Azerbaijan) it will be hard to achieve their national targets due to the number of barriers as well as their industry-based national economies. The prominence of the

oil and gas sector does not allow other industries to develop. Those countries seem to suffer the very well-known Dutch disease, holdings back the development of other sectors and also creating some problems with respect to the development of the energy sector and the modernization of the country as a whole. Carefully-administered resources may turn out to be a worthy development asset, however resources, if used improperly, could also serve to increase vulnerability as well as jeopardizing the economy and political system of the country in which the resources were discovered. In terms of national or international politics, resources are often hotly debated, with arguments frequently breaking out as to which country has a right to access particular resources. As substantial rents can be gleaned in return for allowing access to extract resources, the control of such resources inevitably becomes a key national political issue. Via either patronage or even coercion, funds received for resources may enable political security and consistency (Le Billon, 2004).

In all of the issues covered here, there is great potential for future research, especially regarding the links between resource-rich and resource-poor economies, and the different levels of analysis (international, domestic and political, and economic). The potential of renewable energy in the EU's Eastern Neighborhood is worth analyzing as these countries all have interesting prospects for development in this sector, meaning there are equally intriguing research directions. In a study undertaken by Birdsall et al. (2001) and Wood and Berge (1997), it was confirmed that resource-rich nations tended to amass skills at a slower rate than their resource-poor counterparts. Meanwhile, Auty (2004) showed that, customarily, in resource-rich nations, the uneven sharing of revenue in combination with sluggish urban development tended to obstruct the building-up of social capital and prevented per capita income from increasing. This, in turn, leads to unrest and calls for more democracy and transparency, as has been found in many industrial frameworks in resource-poor nations. Studies into new technology, and particularly renewables, could also help some way toward remedying such problems.

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.

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