System Integration of Renewables for Moldova: A Roadmap

International Energy Agency

Co-funded by the European Union

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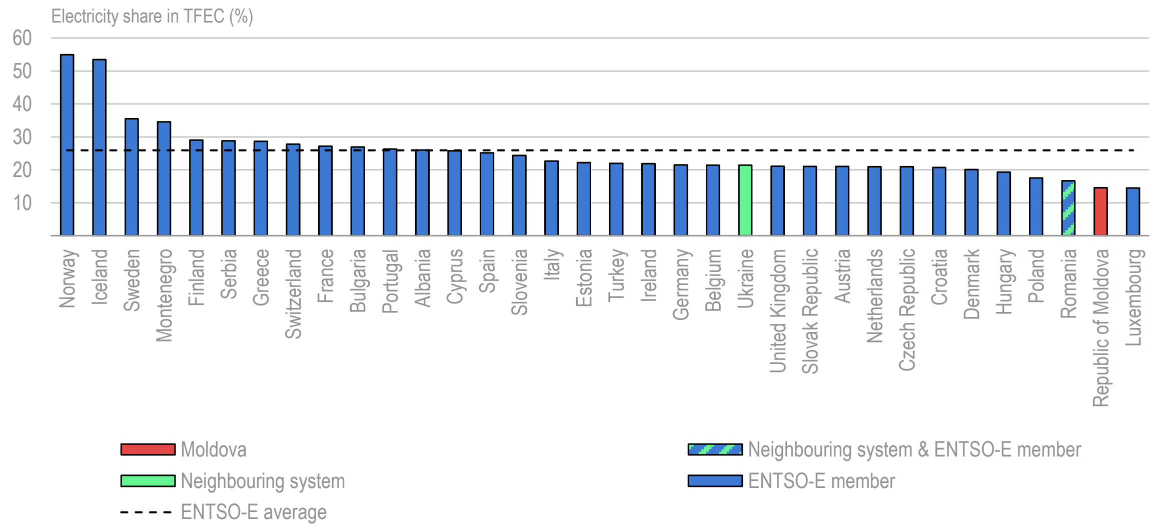
Overview

In 2010, the Republic of Moldova (hereafter "Moldova") became a full-fledged member of the Energy Community, which implied a commitment to adopt core European Union (EU) energy legislation. This has been reflected in its National Energy Strategy (NES) for 2030 which has three key objectives:

- Ensuring the security of supply of energy
- Developing competitive markets and their regional and European integration
- Ensuring sustainability of the energy sector and climate change mitigation.

In Moldova, the security of supply of energy is precariously based on either gas or electricity imports. The share of electricity in the total final energy consumption of Moldova in 2019 was 14.6%, which was the lowest amongst its immediate neighbours (Ukraine and Romania) as well as the other European Network of Transmission System Operators (ENTSO-E) members, except for Luxembourg (Figure 1). The majority of the remaining share of the energy mix was gas, almost all of which came from the Russian Federation (hereafter "Russia") via Ukraine, in addition to petroleum products. Additionally, of the 3.9 TWh of electricity consumption in 2019, 81% was supplied from imports from either Ukraine or the Moldavskaya GRES (MGRES) gas-fired power plant located in Transnistria, a territory which is not under the control of the central authorities. The dominant share of domestic generation came from two cogeneration plants in Chisinau and Balti, respectively, which both relied on imported gas.

Figure 1 Share of electricity in the total final energy consumption (TFEC) for Moldova, neighbouring systems or ENTSO-E members 2019



Source: IEA (2021a), *World Energy Balances 2021* (database).

The development of renewable energy (RE), and in particular RE electricity, could play a large role in achieving a more secure and sustainable supply of energy in Moldova which is clean and domestically derived. An added benefit would be the improvement in the negotiating position of Moldova in terms of the import prices of fossil fuels because of the development and diversification of its energy portfolio. Though it is estimated that Moldova has significant technical potential for wind and solar PV (IRENA, 2019), by the end of 2020, only 72.91 MW had been realised. All power systems have inherent flexibility which allows lower shares of variable renewable energy (VRE), namely wind and solar PV, to be integrated without any noticeable impact on the power system. However, in order to raise their renewable ambitions and significantly increase the share of variable renewables in the energy mix, Moldova will need to transform its electricity system into one that is modern and flexible. The increased deployment of renewables in Moldova would not only benefit the energy sector, but would also have significant positive socioeconomic and environmental benefits for the country including the following:

- Improving energy security, through maximising the consumption of domestic energy resources and reducing reliance on imported natural gas or other fossil fuels.
- Increasing formalised employment in the renewable sector, especially within rural areas where projects are developed.
- Reducing the health impacts from pollution related to both fossil fuel-powered electricity and transport.

With this in mind, the International Energy Agency (IEA) has produced the *System Integration of Renewables for Moldova*: a non-binding roadmap as part of the EU4Energy programme, a five-year initiative funded by the European Union. EU4Energy's aim is to support the development of evidence-based energy policy design and data capabilities within the countries of the Eastern Partnership and Central Asia, including Moldova.

The central purpose of this document is to guide policymaking at all levels related to the increased system-friendly deployment of VRE and to ensure the cost-effective and reliable integration of these resources into the Moldovan electricity supply. This document also serves to support further development of the national renewable energy strategy.

Structure

This roadmap starts with an overview of the prevailing institutional framework related to the renewables and electricity sectors respectively, and the related policy landscape. The wider context of both the renewables and electricity sectors in Moldova is then outlined.

This is followed by the body of the roadmap, which focuses on:

- removing barriers to the deployment of renewables
- establishing flexible electricity markets with enhanced regional co-ordination
- enhancing technical flexibility of the power system

In these three focus areas, a substantial amount of knowledge, experience and expertise has already been accrued by other countries and regions in their own energy transitions. This roadmap therefore provides relevant examples from international experiences with a view to providing an idea of the possibilities for Moldova.

The roadmap outlines specific policies and actionable items in order to apply these international best practice examples, taking into account the particular characteristics of the Moldovan electricity system.

Finally, these recommended actions are put in a co-ordinated package of measures to be implemented for a vision of a secure, clean and modern electricity supply generated from domestic VRE sources. This includes a timeline of measures to be targeted over three distinct periods in the short-, medium- and long-term to deliver this modern electricity system, and in turn provide the social, economic and environmental benefits from Moldova’s clean energy transition.

Key institutions and stakeholders

The cost-effective and reliable integration of renewable energy, and in particular variable renewable energy (VRE) from wind and solar PV, into Moldova's power system is an opportunity for transformation of its electricity sector to one that is less reliant on imports and also based on clean energy resources. The electricity sector and its associated sectors which fall under the jurisdiction of multiple government ministries and departments, include stakeholders from both the public and private sector. A co-ordinated approach to policymaking, governance and market development is therefore required. The following section outlines the main actors in the Moldovan electricity and renewable sectors in the government, and also across other public and private institutions.

Government

While responsibilities are split across various ministries and agencies, the Government of Moldova has a collective role in the development and implementation of RE policy in the country. The government is responsible for establishing the main priorities and realising the objectives of state policy in the field of energy from renewable sources. It is also key to establishing the manner in which activities in the RE sector are organised and managed, including the mechanisms, support schemes and incentives that drive renewable deployment.

The Ministry of Economy and Infrastructure (MoEI), via its Energy Policy Directorate, is the central body for the energy sector, responsible for the development and implementation of energy policy in Moldova. It has a central role in the development of the RE sector as it is responsible for developing support schemes and other incentives for renewables. It also proposes the capacity limits and maximum capacity quotas for RE, including by capacity categories, in connection with the implementation of the aforementioned support schemes, which are then approved by the Government.

The Energy Efficiency Agency (EEA) is an administrative authority subordinated to the Ministry of Economy and Infrastructure, with a wide ranging role in the dissemination of information about the renewable sector to the public, local and regional planning authorities, and relevant actors in the renewable sector. This includes developing programmes, with the participation of local and regional authorities, to inform the public of the benefits and practicalities of developing and using energy from renewable sources. The EEA also ensures that information on support measures is made available to all relevant actors, such as consumers, builders, installers, architects and suppliers of heating, cooling and electricity equipment and systems and of vehicles compatible with the use of energy from renewable sources.

The **National Energy Regulatory Agency (ANRE)** is the state regulator for the energy sector in Moldova. Within this role it provides regulation and monitoring of electricity markets and all activities within the electricity sector, including RE. This includes the calculation and approval of feed-in tariffs (FiTs) for support schemes of small renewable plants. For investment into larger renewable plants, a tendering scheme is envisaged whereby ANRE will propose a ceiling price for tenders. ANRE is by law set up as an institution legally distinct and functionally independent from any other public entity. Its main responsibilities include licences, price/tariff setting and regulation.

The **Moldovan Investment Agency** is a co-operation partner for domestic and foreign investors in development projects, including renewable projects.

The **Ministry of Finance** is the specialised central public administration body to develop and promote the state's public finance policy. As the main public finance supervisor, the Ministry of Finance ensures the regulation and implementation of Public Finance Management policies.

The **Ministry of Agriculture, Regional Development and Environment (MARDE)** is responsible for developing environmental and natural resource management policies and strategies, as well as for implementing international environment treaties. In relation to wind and solar deployment, this includes the management of land-use practices for the development of these plants. It is also responsible for the joint preparation (with MoEI) of the National Energy and Climate Action Plan.

Electricity and renewables sector

There are multiple public and private actors in the electricity and renewable energy sectors in Moldova. These include domestic electricity production companies which include larger combined heat and power plants (CHP) plants (Termoelectrica, CHP-Nord), Cotesti hydropower plant and several smaller private companies that include CHPs in the sugar industry and small renewable electricity plants. In addition, the largest generation company of relevance to the Moldovan electricity system is Moldavskaya GRES (MGRES), a subsidiary of the Inter RAO UES, located in the breakaway region of Transnistria.

Electricity supply in Moldova is dominated by gas-fired generation, including CHPs, and imports from MGRES. **Moldovagaz JSC**, a vertically-integrated company and monopoly supplier of Russian gas controlling the entire chain of gas business outside of direct supply to consumers (import, transit, transmission, wholesale supply and distribution and retail supply) operates under high financial risk. In addition to supplying gas to domestic plants, it also supplies the gas from Gazprom to Transnistria without being paid. The resulting debt accumulation of Moldovagaz to Gazprom at the end of 2019 was USD 6.8 billion (Moldovagaz, 2020), which makes it incompatible with the “going concern” principle, whereby it needs to make have enough revenue to avoid bankruptcy. In its current financial health, its operation can be legitimately seized at any moment.

Moldovatransgaz LLC is the operator of the gas transmission system of Moldova that is responsible for the maintenance and operation of main gas pipelines and their facilities.

SE Moldelectrica is the state-owned single power transmission system operator (TSO) of Moldova, which specialises in centralising the transport services and operative dispatching of the electricity system. SE Moldelectrica manages the internal transmission network on the right bank of the Nistru River.

Electricity distribution in Moldova is comprised of two distribution system operators (DSO). ***RED North*** is 100% state-owned while **Premier Energy Distribution** is privately owned. The latter covers about 70% of the territory of Moldova (excluding the territory left of the Nistru River). **Furnizare Energie Electrică Nord** (state-owned) and **Premier Energy Furnizare** (privately owned), both sell electricity at regulated prices and act as suppliers of last resort in their respective supply areas.

There are also a number of electricity suppliers which sell electricity at non-regulated prices through the wholesale electricity market. **Energocom JSC,** which is also the designated Central Electricity Supplier and single buyer for both renewable and cogenerated electricity, is a state-owned electricity supplier and trader on the wholesale market. In the past, it has also participated in tenders to manage electricity annual import contracts with Ukraine and MGRES. It also covers imbalances for eligible producers of renewable electricity. While another 43 suppliers are currently licensed by ANRE, a large part of these suppliers are not active on the electricity market. In 2019, the share of electricity sold by retailers on a competitive market was 7.4%, with this share then increasing to about 9.6% in 2020 (Moldelectrica, 2021a).

Current policy landscape for renewable electricity

In 2013, Moldova adopted its National Energy Strategy (NES) for 2030. The NES, which is currently under revision, was driven by three main objectives:

1. Ensuring the security of energy supply.
2. Developing competitive markets as well as their regional and European integration.
3. Ensuring sustainability of the energy sector and climate change mitigation.

In 2010, Moldova became a full-fledged member of the Energy Community, which implies a commitment to transpose core EU energy legislation. Since then, governmental efforts have been focused on aligning the national legal framework for energy with that of the EU. Moldova has successfully adopted legislative and regulatory acts which transpose the Third Energy Package at the level of primary legislation. However, the progress in adopting the secondary legislation and the actual implementation of the Third Energy Package provisions have been uneven across various sub-sectors, as discussed later in this section.

Efforts have also been made to adjust national legislation in the field of renewable energy and energy efficiency, and to diversify gas supply routes. Most of the RE-related legislation has been transposed except for provisions relating to biofuels and bioliquids that are produced or placed on the market.

In 2016, Moldova signed the Paris Agreement on climate change and ratified the agreement in June 2017. In its Nationally Determined Contribution (NDC) document, Moldova set an unconditional target of reducing national GHG emissions to 64-67% below the 1990 level by 2030. In March 2020, Moldova submitted its revised NDC to the United Nations Framework Convention on Climate Change (UNFCCC), becoming only the fourth country in the world to do so at the time. With this second NDC, the country increased its ambition and committed to unconditionally reducing GHG emissions by 70% below its 1990 level by 2030 and by up to 88% while receiving technical, financial and technological support from the international community.

In 2020, Moldova had binding renewable targets for both gross national energy consumption and individual sectors (electricity, heating and transport). Preliminary statistics for 2020 estimate that Moldova had a 23.56% share of energy consumption from renewable sources, which was above the 17% target for 2020 (IEA, 2021b). However, this was achieved mostly through the revision of biomass consumption data for the years 2010-2016. As a result, the achievement of this target does not accurately reflect the progress made by the country towards the transition to renewable sources. In addition to the target of 17% of total energy consumption from renewables, the target also includes sector-specific non-binding targets of 10% of electricity consumption, 27% of heat consumption and 10% of fuel consumption for transport to come from renewable sources. The MoEI and the Energy Community have started discussions on adopting new RE targets for Moldova in the frame of the National Energy and Climate Action Plan development exercise.

Currently, high expectations are set for the implementation of the **Law on the Promotion of the Use of Energy from Renewable Sources**,[1] which entered into force in 2018. This Law provides support mechanisms for the so-called eligible producers of RE. There are three support levels according to the project size: net metering for plants up to 200 kW, administratively-set FiTs for small-scale projects and auctioned fixed prices for larger projects. The central electricity supplier Energocom has an obligation to purchase all eligible renewable-generated electricity for 15 years at a determined tariff/price. Eligible producers also benefit from non-discriminatory grid connection and priority dispatch. The law is expected to lead to the construction of up to 168 MW of new capacity, mainly wind and solar PV (by 2020), while the period between 2021 and 2025 will be subject to a different Government Decision that is currently under public consultation.

[1] Transposes the Directive 2009/28/EC and the EC Guidelines on State aid for environmental protection and energy 2014-2020. The Ministry of Economy and Infrastructure is currently analyzing the Clean Energy for all European package with the aim to transpose it into national legislation.

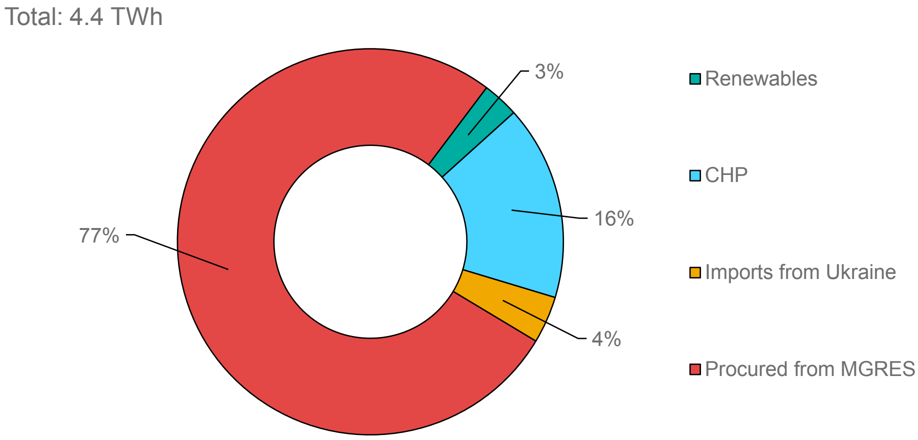
Context of renewables in Moldova's electricity sector

Electricity sector

Electricity supply

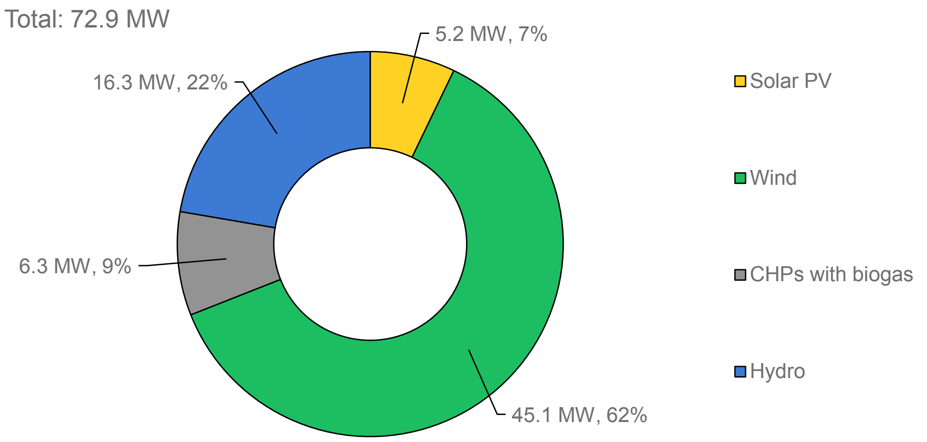
The electricity system in Moldova is characterised by its reliance on imports. In 2020, of its 4.4 TWh of electricity demand, 81% was supplied by imports, either from Ukraine (4%) or from the Cuciurgani-Moldavskaya GRES (MGRES) gas-fired power plant (77%) located in the breakaway region of Transnistria (Figure 2). This is roughly the same share of imports as 2019, although there was a significant decrease in imports from Ukraine in 2020 relative to 2019, with only 26% of the traded volume (167 GWh vs. 644 GWh) which was largely compensated by an increase in imports from MGRES. The balance of domestic supply comes from a combination of CHP plants (~ 330 MW) and small renewable energy plants (72.9 MW), with the share of RE generation as of December 2020 detailed in Figure 3.

Figure 2 Share of generation sources for electricity supply in 2019



Note: Renewable energy includes hydro (1.5%), biogas (0.7%), wind (1.0%) and solar PV (0.7%) generation. Oil accounted for only 0.1% of supply in 2019.
Source: IEA (2021a), *World Energy Balances 2021* (database).

Figure 3 Installed renewable capacity in Moldova (as of December 2020)



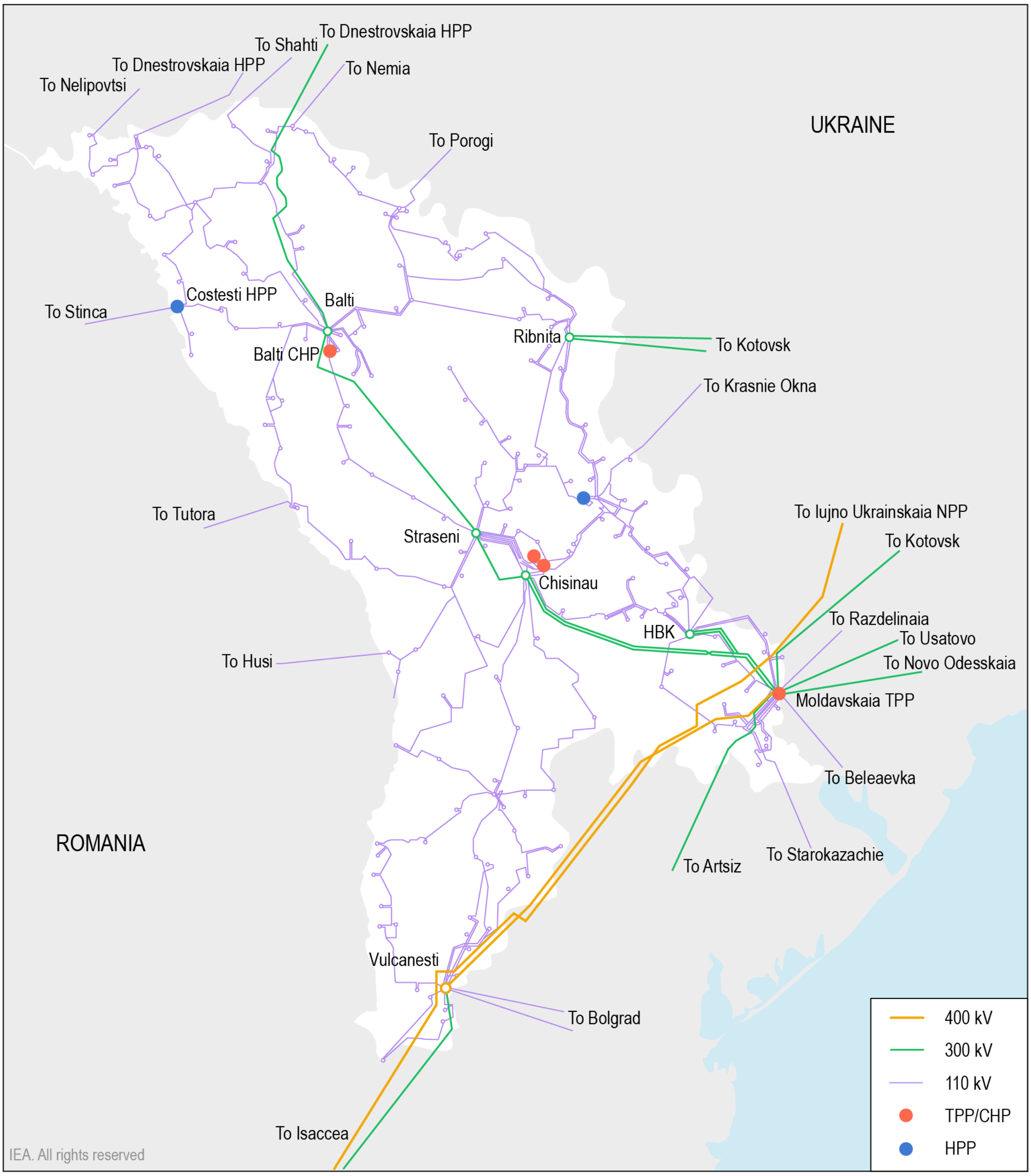
Source: MoEI data on request from IEA.

Moreover, the country is completely reliant on imports for natural gas and all oil products, which fuel the majority of its domestic supply in the form of CHP plants (~330 MW). This includes an almost 100% reliance on gas imports from Russia, although recent efforts have been made to diversify Moldova's gas supply by interconnecting with Romania in addition to modifications on the gas network of the trans-Balkan Corridor, on which Moldova is a transit country, to allow reverse flows.

Electricity grid and interconnections

Moldova's electricity grid (Figure 4) was predominantly built in the time of the Soviet Union, making it relatively old and inefficient. It is synchronously interconnected with Ukraine's Integrated Power System (IPS) and, in turn, Russia's Unified Power System (UPS) in the northern and south-eastern parts of the grid. While there are transmission lines connecting Moldova's electricity to Romania, the grid cannot operate synchronously with Romania's electricity system, which is part of ENTSO-E's Continental Europe Synchronous Area and has stricter regulations for the technical operation of its network. Hence, with ENTSO-E it is limited to operation in island mode, allowing only very small amounts of trade. In order to interconnect synchronously with Continental Europe Synchronous Area via Romania, significant effort would be required in terms of rehabilitation and modernisation of generators, lines and substations, which are relatively old and inefficient, falling short of ENTSO-E technical requirements. Rehabilitation of the network is ongoing, supported mainly by international financial institutions such as the World Bank (WB), European Bank for Reconstruction and Development (EBRD) and European Investment Bank (EIB). Furthermore, the current electricity system is based on Russian technical standards (GOST), with all employees in the electricity sector used to these standards. On the other hand, ENTSO-E uses International Electrotechnical Commission (IEC) standards, which represent a large barrier for Moldovan electricity companies to overcome as they would therefore need to convert to IEC standards in order to operate synchronously.

Figure 4 Existing electricity transmission network in Moldova



Source: Moldelectrica (2017), *Plan de Dezvoltare a Rețelelor Electrice de Transport în perioada anilor 2018-2027* [Development plan for the electrical transmission networks in the period 2018-2027].

Prior to the synchronous interconnection with Continental Europe, Moldova aims to connect asynchronously with Romania via High-Voltage Direct Current (HVDC) back-to-back converters, with a memorandum of understanding (MoU) concluded between the two countries in 2015 on five key projects for interconnecting both their electricity and gas systems. It included three projects for asynchronous connection of the electricity networks in the north, central and southern parts of Moldova. The asynchronous interconnection in the southern part (Isaccea – Vulcanesti – Chisinau) has started and will consist of the construction of a new 400 kV power line from Vulcanesti to Chisinau and a back-to-back substation of 600 MW in Vulcanesti. The financing for the project has been agreed through an EU grant of 40 million Euros and loans from EBRD, EIB and the WB.

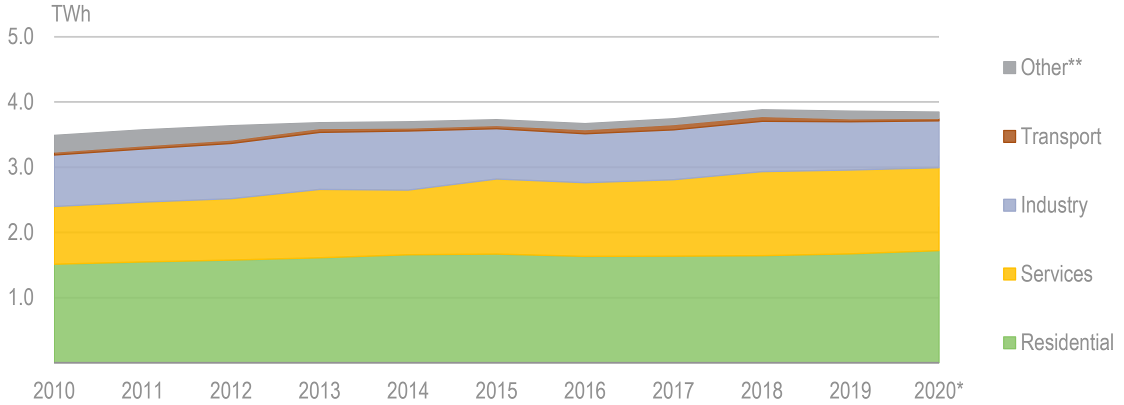
Electricity market

The wholesale electricity market, in its current shape without a spot market, is based on a number of bilateral contracts between transmission and distribution companies, generators, and power suppliers (traders). In its current state, it suffers from a lack of competition, and is mainly limited to imports from Ukraine or the Moldavskaya GRES (MGRES) plant situated in Transnistria, which together supplied 81% of electricity demand in 2019 and 2020. The imports from Ukraine and Transnistria are concluded on an annual basis through a tendering procedure. The Law on Electricity (Law No. 107 of 27.05.2016) will ensure the liberalisation of the electricity market. The design for the operation of the new wholesale electricity market and the detailed wholesale electricity market rules were approved in August 2020 and will entered into force on 2 October 2021.

Electricity demand

The total electricity consumption in Moldova was 3.9 TWh in 2019, which was up 11% from its level in 2010 (Figure 5), with the majority of consumption from the residential sector (43%). Residential consumption grew by 10.4% between 2010 and 2019, which is considerably less than the global average growth for the same period, which was over 20%. While Covid-19 had a significant impact on electricity demand of Moldova in 2020, this was continuing a declining trend from the previous year where demand decreased by 0.54% in 2019 and then a further 0.38% in 2020 based on preliminary data (Figure 5).

Figure 5 Electricity consumption by sector, 2010-2019

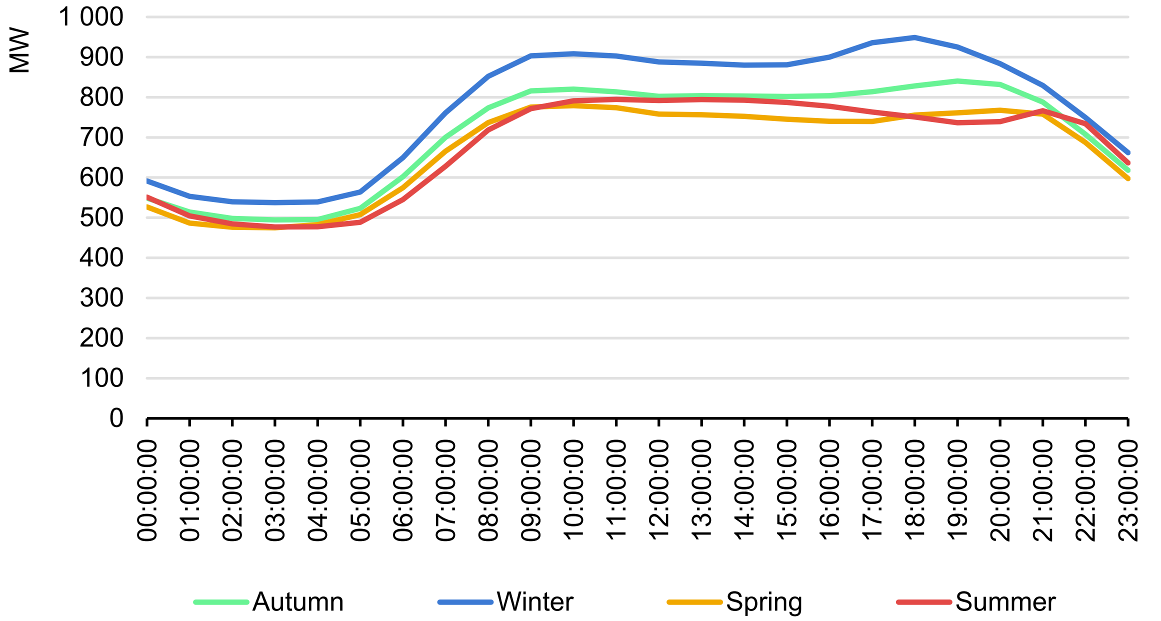


Notes: * Preliminary data, ** Includes energy sector own use and agriculture.
Source: IEA (2021a), *World Energy Balances 2021* (database).

As part of the Energy Community, Moldova had a binding 10% contribution target for renewable sources (from either electricity, biofuels or hydrogen) in its transport sector by 2020. This target was not met. However, the Energy Community has also started to consider the implementation of a revised Renewable Energy Directive (RED II) on the promotion of energy from renewable sources. If fully transposed into Moldovan law, this would set a target of 9% of renewable sources in the transport sector in Moldova by 2030. A study conducted for the Energy Community estimates that this target would be met mostly by biofuels (8.8%), while a combination of battery electric vehicles (BEVs) and hydrogen fuel cell-electric vehicles (HFCEVs) would be required to meet the rest of this target (Energy Community, 2020). Electric vehicles (EVs) could therefore play a growing role in future electricity demand.

Electricity demand in Moldova is characterised by a winter peak demand. The typical load variation in the winter season, based on 2019 operational data is between a minimum base load of 540 MW and a maximum peak load of 950 MW, while in the summer, it varies from a minimum of 480 MW and a peak load of 800 MW (Figure 6). Therefore, the demand typically almost doubles between peak and off-peak periods in both winter and summer, with a fairly flat demand during the day.

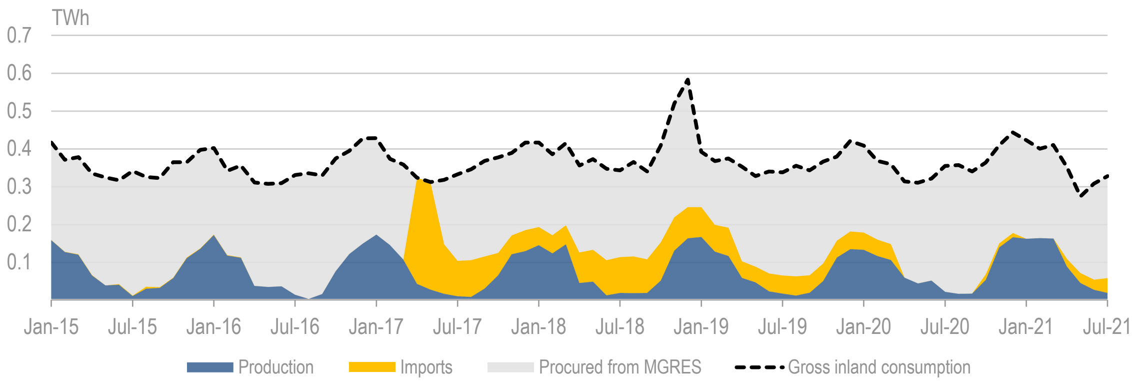
Figure 6 Average forecasted daily electricity demand by season in Moldova in 2019



Source: Moldelectrica (2021b), *Surse regenerabile de energie* [Renewable energy sources].

In the winter, the cogeneration units in Chisinau and Balti are operated as must-run due to heating demand, and therefore account for between 200 and 260 MW of generation during these periods. The monthly supply of power in terms of domestic production and imports from MGRES and Ukraine is shown in Figure 7 and shows a strong seasonal pattern peaking in January and accompanied by an increase in domestic production from CHPs.

Figure 7 Moldova's monthly electricity supply, January 2015 to January 2021

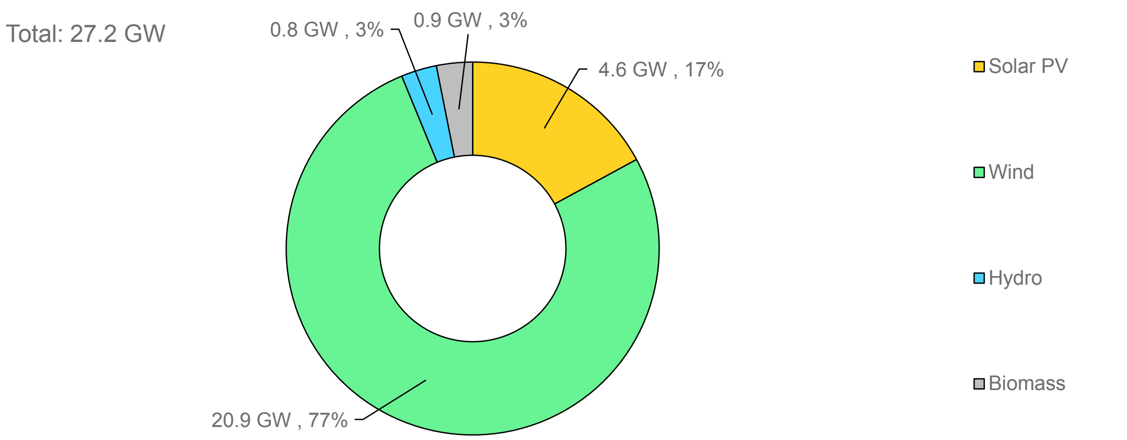


Source: IEA (2021a), *World Energy Balances 2021* (database).

Renewables sector

According to an analysis of technical potential for RE generation (IRENA, 2019), there is in excess of 27 GW of potential renewable generation capacity in Moldova, including 20.9 GW and 4.6 GW of wind and solar potential respectively, in addition to both biomass and hydro potential (Figure 8).

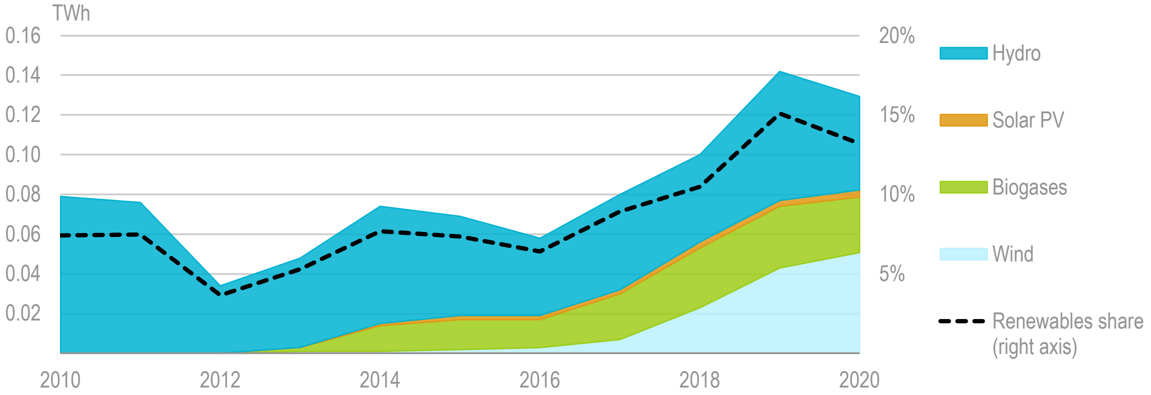
Figure 8 Technical potential of renewable electric generation by technology



Source: IRENA (2019), *Renewables Readiness Assessment: Republic of Moldova*.

Despite the large potential for wind and solar power, its deployment has been very modest to date, with only 72.9 MW of installed capacity at the end of December 2020 (Figure 3). However, there are high expectations set upon the further implementation of the Law on the Promotion of the Use of Energy from Renewable Sources, which was adopted in 2016. The law provides support mechanisms for the development of RE plants at three separate levels according to the size of the project and aims to help achieve the targets set in the National Energy Strategy which stipulates that 10% of electricity generation should be provided by RE generation by 2020. In 2020, RE (including wind, solar PV, hydro and biogas) accounted for just over 13% of domestic generation, which excludes generation in Transnistria (Figure 9).

Figure 9 Moldova electricity generation from renewable sources



Source: IEA (2021a), *World Energy Balances 2021* (database).

The support mechanisms for these new plants are offered at three different levels according to the project size: net metering for plants up to 200 kW, administratively-set FiTs for small-scale projects and auctioned fixed prices for larger projects. The central electricity supplier, Energocom, has an obligation to purchase all eligible renewable-generated electricity for 15 years at a determined tariff/price. Eligible producers also benefit from non-discriminatory grid connection and priority dispatch. By the end of 2020, 35.6 MW of solar PV and 55 MW of wind had been procured through either FiTs or competitive auction, in addition to at least an additional 35-40 MW (as of the end of 2019) which is supported under a net metering scheme. However, the MoEI is currently exploring the amendment of these aforementioned categories of RE and their respective capacity limits, with the decision currently under public consultation, as the government aims to increase the capacity of RE (including a large portion of variable renewables) that are procured as eligible producers.

The pool of eligible producers which currently benefits from the aforementioned support mechanisms, comes from a larger pool of more than 1.2 GW of renewable plants which have connection permits to the grid (Moldelectrica, 2021b) . Those plants that do not qualify for support mechanisms do not have priority dispatch but can still implement projects under normal market conditions.

Mapping a pathway towards system integration of renewables in Moldova

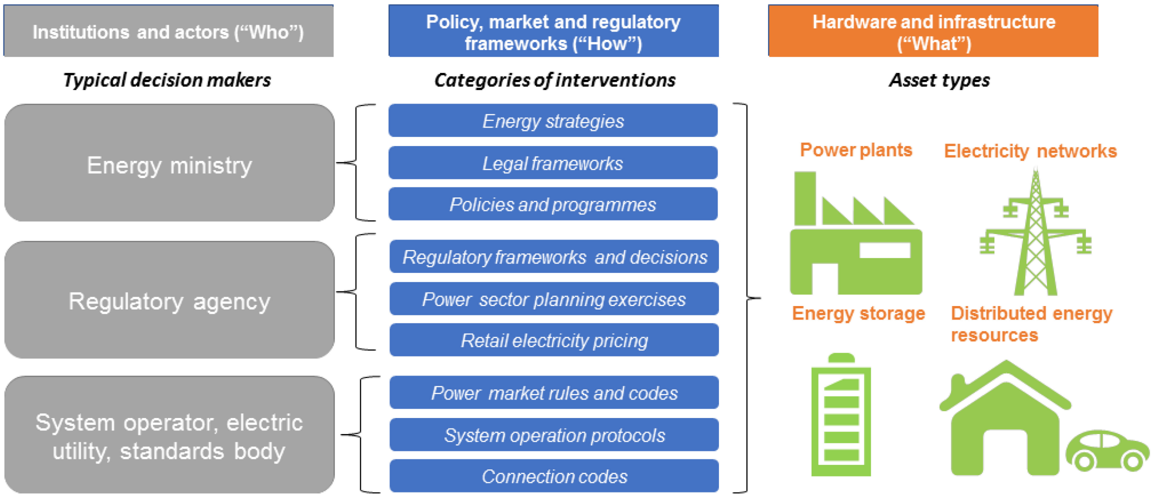
The transition of the Moldovan power system from one that depends on imports and fossil fuels to one that is more self-reliant on domestic, renewable resources requires actions in two main areas. Firstly, an environment must be created that removes barriers for entry, encourages investment and mobilises finances for the deployment of renewable technologies. Secondly, Moldova needs to transition its power system to one that is flexible so that it can integrate the developing shares of variable renewables.

Power system flexibility is defined as “the ability of a power system to reliably and cost-effectively manage the variability and uncertainty of demand and supply across all relevant timescales, from ensuring instantaneous stability of the power system to supporting long-term security of supply” (IEA, 2019a).

Flexibility is already an important characteristic of all power systems, as they have been required to be able to respond to changes in electricity demand or sudden generation or transmission equipment failure. However, with the increasing prominence of VRE in global power systems, there has been a growing need to actively evaluate their inherent flexibility while planning and transforming systems to become more flexible.

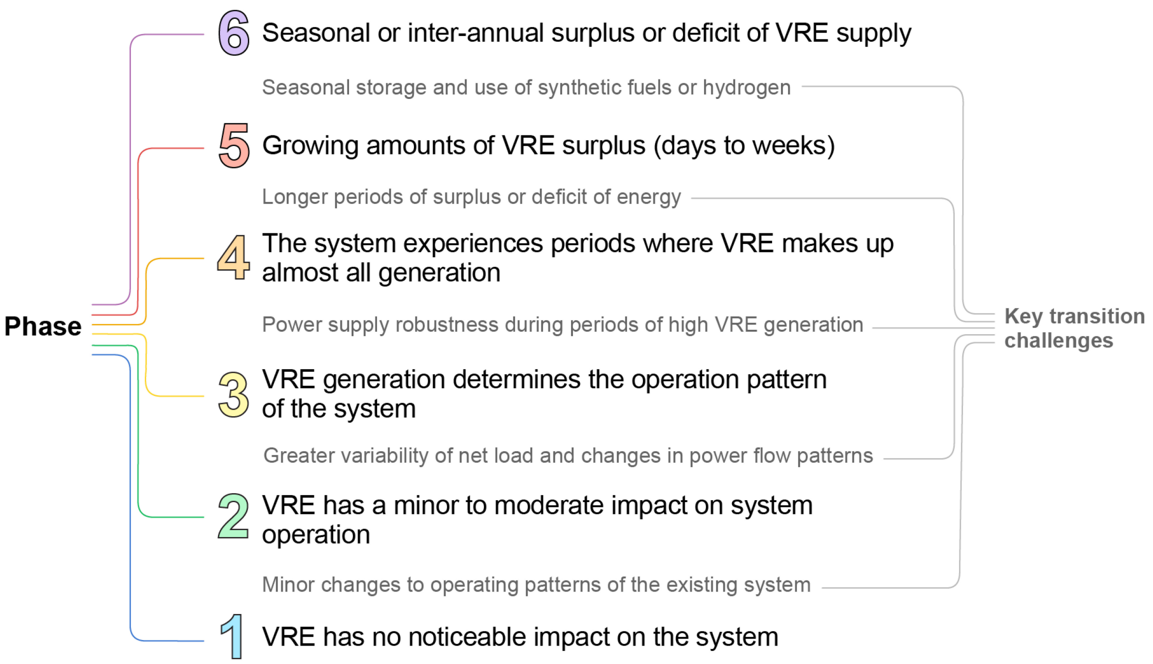
There are four main flexibility resources: power plants (both conventional and VRE), electricity networks, storage and distributed energy resources. Appropriate policy, market and regulatory instruments are required to harness their full potential for flexibility. These options can be grouped into several categories of actions at various levels of decision making, as depicted in Figure 10.

Figure 10 Layers of power system flexibility



Source: IEA (2019), *Status of Power System Transformation 2019*.

Figure 11 Key characteristics and challenges in the different phases of system integration



Source: IEA (2020), *Power Systems in Transition*.

In order to capture the evolving impacts of VRE on power systems, and the resulting system integration issues, the IEA has developed a phase categorisation for systems under transition. The integration of VRE can be categorised into six different phases, with each phase having its unique set of challenges and potential solutions. This framework can be used to prioritise different measures to support system flexibility, identify relevant challenges and implement appropriate measures to support the system integration of VRE (Figure 11).

While renewable deployment is quite low in Moldova at present, meaning it is only in Phase 1 of the integration of VRE challenges, current policy targets and the potential for switching to a more sustainable and secure energy resource mean that there is great potential for growth in the sector. As a result, it is important to start assessing flexibility requirements to accommodate future growth of VRE, especially as many measures may have a considerable lead-time for actual implementation.

In order to explore the possible pathways that are open to Moldova to support the accelerated deployment of VRE in its power system, this section looks at the transition to renewables across three main themes:

- Removal of regulatory barriers and increasing attractiveness to investors.
- Establishment of flexible electricity markets with enhanced regional co-ordination.
- Enhancement of the technical flexibility of the power system.

Removal of regulatory barriers and increasing attractiveness to investors

The removal of regulatory and fiscal barriers to the development of renewables is vital for stimulating investment in the sector. Despite the adoption of the Law on the Promotion of Renewable Energy, following from the adoption of the primary legislation of the Third Energy Package, there is a lack of consistent policy to follow through on the promises of this law. Clear and transparent guidelines for technical requirements for connection to the grid, long-term off-take agreements, consistent customs or tax breaks with other specialised imports and reasonable policies for rezoning or sharing land and the building of necessary shared infrastructure (e.g. access roads) are all necessary to increase the attractiveness of developing renewables in Moldova.

International best practice in stimulating the RE sector

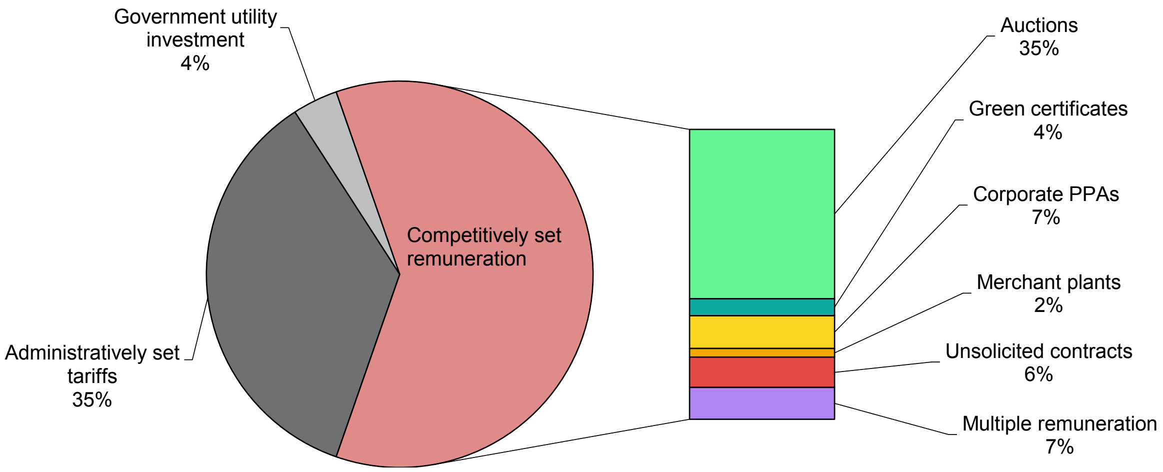
Ensuring sufficient investment in clean power generation

Investment in new generation capacity requires sufficient long-term visibility of expected revenues. This is true irrespective of the policy, market and regulatory frameworks. In a vertically-integrated, regulated monopoly this certainty is provided by the regulator, which allows the monopoly to recover its cost from consumers. In an environment of competitive wholesale markets, forward markets play a critical role in providing sufficient visibility several years ahead. However, the large-scale uptake of renewable energy and other low-carbon energy sources can challenge both of these approaches.

For example, in the regulated environment, incumbent utilities often face challenges in accessing low-cost capital to shoulder the upfront investment in clean generation options. Both renewable energy plants and associated flexible infrastructure, such as storage and grid infrastructure, have in common the fact that they incur significant upfront costs but low operational costs. Hence, the cost at which financing can be obtained has a critical impact on the overall costs of these projects. Up until now, this situation has been resolved by creating a dedicated off-taker that has sufficient financial credibility, and procuring generation capacity via a competitive auction for long-term power purchase agreements (PPAs) (IEA, 2017a).

As the global VRE industry matures, governments and utilities are moving towards competitive procurement mechanisms to attract competition and drive down costs. This trend is occurring in markets with a diversity of institutional frameworks, including those with wholesale power markets. These competitive procurement mechanisms still offer long-term contracts, but the ultimate price of the contract is discovered through competition. A rapid shift from administratively-set FiTs to competitively set remuneration schemes for renewable plants (both utility-scale plants and large-scale distributed PV projects) has been occurring since 2015. From the forecasts in RE growth for the period 2020-2025, over 60% of developments will be under competitively set remuneration (Figure 12).

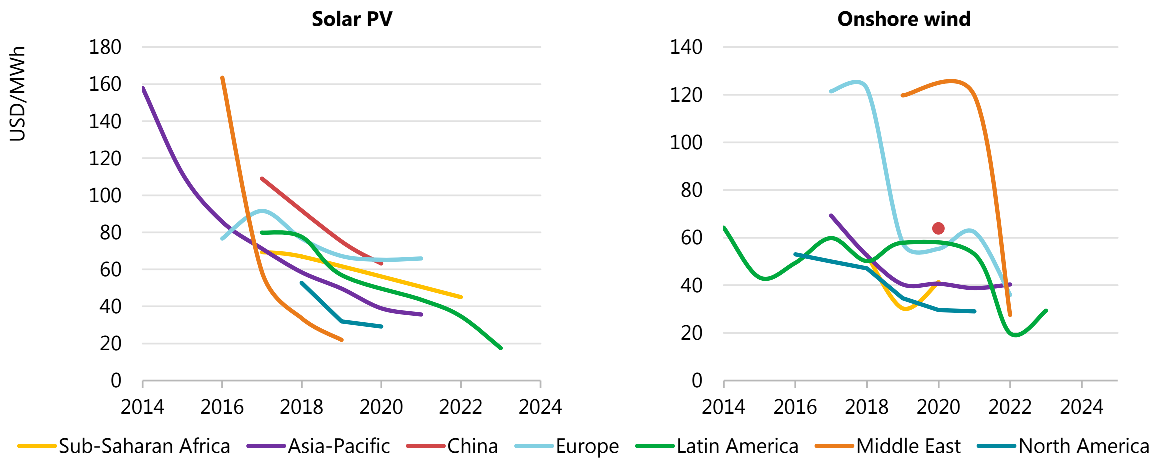
Figure 12 Renewable electricity capacity remuneration policy types, 2020-2025



Note: Unsolicited contracts are bilateral contracts between a power producer and the utility.
Source: IEA (2020), *Renewables 2020*.

This trend is clear even in relatively immature markets such as Africa and Latin America, and has had a positive effect on the contract prices for wind and solar, driving down auction prices (Figure 13).

Figure 13 Average auction price by region and commissioning date



Source: IEA (2019), *Renewables 2019*.

In most cases of a competitive procurement framework, a government or utility issues a call for proposals or tenders for a specified amount of generation capacity or energy. VRE developers then submit bids to supply the capacity or energy, and the government or utility evaluates proposals based on price competitiveness, a host of technical criteria, and in some cases economic development or social impact criteria. When a proposal is accepted, the electricity off-taker enters into a PPA with the VRE project owner. The awarded PPA can be a fixed-price contract, or another pricing mechanism such as a Contract for Difference (CfD) or a market premium (IEA, 2017a).

Properly designed, auctions can help ensure transparency, increase levels of participation, and reduce uncertainties and delays. They can also enable different technologies to compete with one another. Auctions can also be designed to include elements that ensure VRE deployment is done in a relatively system-friendly way, for example by including locational requirements or by aligning results with grid development (IEA, 2017a).

Auctions have been instrumental in lowering the price for wind and solar projects globally, including in other systems close to Moldova which are also navigating the initial barriers to VRE deployment. In 2018, Albania, Armenia and Kazakhstan completed their first auction rounds, with PV prices averaging USD 58 per megawatt hour (/MWh) and onshore wind clearing at USD 53/MWh (IEA, 2019b).

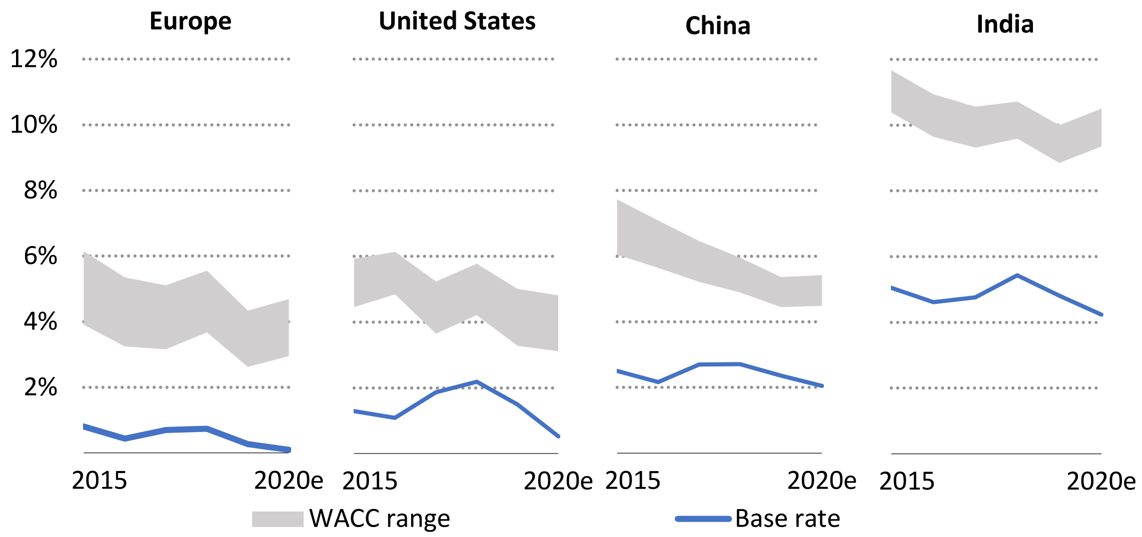
Costs of financing can be driven down through good policy

As an emerging sector in Moldova, RE requires an investment environment that both stimulates and protects the relevant actors in the sector. This should be from the perspective of both public and private financing opportunities. The Covid-19-driven economic downturn in 2020 had a strong negative (-14.9%) impact on investment in Moldova. Public finances are facing additional pressures due to the fall in tax and customs revenues and the sharp increase in public spending to support the healthcare system and social assistance programmes. However, international experience and action plans suggest that government efforts which focus on green recovery policy packages have a potential to stabilise or revitalise the investment downturn of 2020 (OECD, 2020).

In terms of private equity, a reduction in financing costs has been vital to scaling up deployment globally. For example, applying a standard real weighted average cost of capital (WACC) of 8% to a solar PV project in the US in 2019 would lead to a levelised cost of energy (LCOE) of around USD 80/MWh, while the same project with access to lower-cost financing (around 4%) was just over USD 50/MWh (IEA, 2020b).

Aspects which pose a risk to potential revenues (and therefore investment) include price, volume and off-taker risk (IEA, 2020c). As the perceived risk of a market increases, so do the financing costs for the project due to a higher required rate of return for any equity capital. Globally, a combination of strong policy support and maturing technology has helped reduce private investors' and financial institutions' risk perception for wind and solar PV projects. This has in turn helped to lower the cost of financing for projects provided that they have some type of long-term support mechanism (IEA, 2020c). This can be seen in the WACC trend for solar PV projects (all under support mechanisms of some type) in different regions around the world (Figure 14), although the WACC trended upwards in 2020 due to increased uncertainty in the renewables markets caused by Covid-19.

Figure 14 Indicative weighted average cost of capital for utility-scale solar PV projects with revenue



Source: IEA (2020c), World Energy Outlook 2020.

Integrated planning and co-ordination can minimise costs and maximise system resilience

In many jurisdictions, increasingly integrated and co-ordinated planning frameworks have played a key role in the cost-effective and secure transition to a new electricity mix. While this is predominantly the case in vertically-integrated utilities, it can still be useful in unbundled systems to guide project developers, system operators (SO) and authorities. Co-ordinated and integrated planning practices that are emerging can be broadly categorised into (IEA, 2017a):

- integrated generation and network planning and investment
- inter-regional planning across different balancing areas
- integrated planning across a diversity of supply and demand resources (and other non-wire alternatives)

- integrated planning between the electricity sector and other sectors

The importance of integrated generation and network planning is magnified as the level of VRE deployment increases because the development of VRE projects can easily outpace the development of network infrastructure. Geographic concentrations of VRE in areas with high resource potential can push up against the limits of the electricity network, which ultimately drives up the cost of delivered electricity.

The renewable-energy-zone (REZ) approach has been adopted in several jurisdictions, which brings together network planning and the development of RE projects. REZs are geographical areas that are characterised by high-quality RE resources, potential for grid integration and strong developer interest. The process to establish REZs requires co-ordination from relevant stakeholders in the energy sector, including the regulator, utilities and potential RE developers.

The success of this approach is partly due to the fact that network expansion can be started ahead of constructing generation plants, to allow for its longer development timeline. In addition, developing co-ordinated network investment for multiple VRE generators increases efficiency relative to planning infrastructure on an individual project basis.

Jurisdictions that have adopted the REZ approach include South Africa and the Electric Reliability Council of Texas (ERCOT). Most recently, the Australian National Electricity Market (NEM) has been developing REZs as part of the Integrated System Plan (ISP) to identify transmission developments to reduce overall costs. Considering the strong need for grid upgrades in Moldova to meet both growing demand and defined strategies for interconnection, there could be an even stronger benefit from a co-ordinated approach to transmission development which unlocks grid potential for new VRE projects in Moldova, boosts investor confidence for project development and works towards other priorities as per the NES.

Integrated planning between the power sector and other sectors

Integrated planning that spans the power and other sectors is a growing field in energy system integration. Historically, planning across different sectors was thought to be relevant to only the electricity and gas sectors, since gas is one of the main fuels for electricity generation in many countries. However, even power and gas planning have been carried out separately in many countries due to a number of challenges, particularly from institutional and regulatory perspectives.

Efforts have been made in many jurisdictions to link the planning of electricity and gas. In the European Union, the European Commission has encouraged electricity planners to work with gas partners in the ENTSOG (European Network of Transmission System Operators for Gas) to create a common baseline of assumptions. This involves using the same analytical basis for their respective ten-year network development plans. These plans would then be used as the basis for the cost-benefit analysis of different electricity and gas network expansion or reinforcement projects.

In addition, linking the power and transport sectors can also support development and planning of necessary infrastructure for both EVs and the distribution network. For example, to enable a greater uptake of EVs, there will be a growing need to roll out EV charging infrastructure. At the same time, this growth in demand for electric mobility will place additional strain on the distribution network, and may result in local congestion due to the clustering of EV charging. This could occur due to strong uptake of EVs, concentrated charging (e.g. fleet depots or multi-dwelling buildings) or high power charging, such as that required for light-commercial vehicles, trucks or buses (IEA, 2020a).

More recently, continuing innovation in and uptake of demand-side technologies are having an impact on the power system. Demand-side technologies, particularly EVs, have the potential to facilitate a high share of VRE in the power system. Such technology options can be deployed in a way that increases the flexibility of the system. For example, time-of-use tariffs, dynamic electricity pricing or dynamic controlled charging of vehicles (V1G) can provide large benefits to the system for the integration of variable renewables, by incentivising charging during periods of high VRE output (IEA, 2020d).

Key policies for providing a stable environment for investment in RE technologies

Key overarching principles:

- Ensuring the economic attractiveness of renewable projects to investors through the removal of unnecessary administrative burdens and taxation, and through the provision of financial guarantees.
- Developing the capacity of local banks in Moldova to facilitate the financing of clean energy projects.
- Robust implementation of integrated planning in the electricity sector to allow adequate investment in associated infrastructure and proper identification of bottlenecks.

- Implementing well-designed and transparent auctions which allow a fair, competitive and open process with PPAs that are drafted according to best international practice and open to public consultation.
- Developing support mechanisms that allow de-risking of projects for developers while still minimising market distortion and allowing market signals to act as a guidance for development of projects where they are most needed.

Specific policies and actions for consideration

Removal of entry barriers

Generally, barriers preventing or making it difficult for project developers and investors to access the electricity market should be eliminated. In particular this may refer to administrative procedures, contractual negotiations, grid access, taxation as well as access to the land. Policymakers should address the issue of cost (rezoning, taxation) and availability of land (competition or shared use) for renewable power plants in order to minimise entry barriers for market players and investors in renewable energy.

Policymakers should aim to reduce investment risk through the inclusion of financial guarantees within long-term PPAs. However, to avoid market distortion and to ensure that developers are still guided by market signals, these guarantees should be in the form of market premiums (either fixed or sliding).

The Government of Moldova should reinforce the public-private dialogue on energy policy matters, and develop a communication strategy for sector stakeholders, as well as the population at large on renewable energy strategies and the challenges, benefits, opportunities and costs of the ongoing reforms. This should include communication about the potential opportunities to become active players in the transition to renewables through private or community participation.

Policymakers should ensure a level playing field in the energy sector by phasing out tax distortions created by reduced VAT on natural gas and zero VAT on electricity and heat for residential consumers.

Integrated planning

Policymakers should assign the responsibility of assessing the technical feasibility of grid integration to a technically competent and neutral body such as the transmission system operator (TSO) and/or the electricity regulator. This should avoid the use of arbitrary caps, or approaches intended for conventional power plants.

Policymakers and regulators should encourage the integration of generation and network investment planning during long-term planning exercises. While transmission and distribution investments are already considered during most system planning exercises, they are often considered separately from generation investment exercises. However, network investment decisions have strong implications for system flexibility requirements. Policymakers and regulators can help ensure that transmission and distribution planning processes are better integrated with generation planning, particularly as the latter begins to include a more holistic consideration of system flexibility.

Current electricity market prices are high enough to support the development of local, renewable resources in Moldova. In the long run, the aim of the government could be to transform Moldova from a net electricity importing country to a net exporting country driven by renewable production.

Policymakers should request the use of state-of-the-art decision support tools in all aspects of power sector planning by all relevant stakeholders (e.g. the TSO, market operator and regulator). This would allow for a better understanding of flexibility requirements and prioritise efforts in the short-, medium and long-term. This may include timely development in key shared infrastructure (e.g. transmission network development and EV charging infrastructure), and market design that ensures appropriate investment in generation and flexibility assets that allow the achievement of national climate and energy goals in the most cost-optimal manner.

Procurement of renewables and flexibility

The regulator should assess options for cost allocation, including cost sharing among developers, and contributions from the public purse, which may be recovered subsequently from developers, consumers or taxpayers.

The SO should refer to state-of-the-art industry standards and international experiences when identifying the technical requirements for connecting VRE plants, modifying international standards to suit the local context.

The SO should start with requirements appropriate to a low VRE share while preparing for higher shares of VRE based on international experience. These include ranges of operation, power quality, visibility and control of large generators, in such a way that they do not discourage initial investment and allow growth of the market. These will need to be adjusted regularly as deployment grows.

Establishment of flexible electricity markets with enhanced regional co-ordination

Policy, market and regulatory frameworks have a strong bearing on the way in which decisions relating to power system operations are made. In recent years, there has been growing global interest in the establishment or strengthening of wholesale electricity markets worldwide to improve the operational efficiency of the power system and better incorporate higher shares of VRE. The drivers behind this include the potential for savings through making better use of existing assets, in particular across larger geographical regions and allowing market operations closer to real-time.

Recent improvements to the design of short-term markets have focused primarily on: enabling trading closer to real time, improving pricing during periods of scarcity, reforming markets for the procurement of system services, allowing for trade over larger geographical regions, and better incorporating VRE and distributed resources into the system dispatch. The latter is especially enabled through advanced weather forecasting (as discussed later in this section).

International best practice in increasing power system flexibility

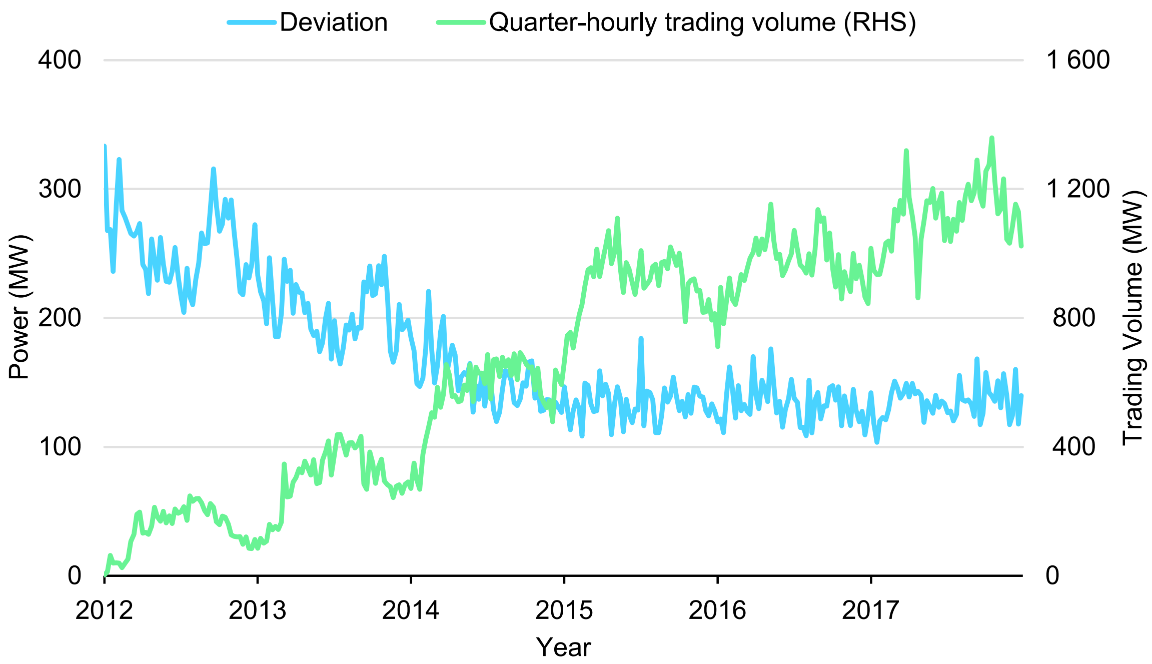
Moving operational decisions closer to real time can unlock flexibility

Technical constraints of the power system call for a certain degree of forward planning and scheduling with regard to system operation. In practice, however, many power systems tend to lock in operational decisions far more in advance than technically required, sometimes weeks or even months ahead. Such a situation is undesirable for least-cost system operation, in particular at high shares of VRE penetration where the error in forecasts in wind and solar production becomes smaller as one approaches real-time. These forecast errors are then needed to be balanced by reserves. Considering that Moldova does not currently have any domestic reserves, this is an aspect which is particularly relevant for increased deployment of variable renewables.

In regions where the share of VRE is on the rise, steps have been taken to improve the trading arrangements for electricity closer to real time. Scheduling and dispatch that are as close to real time as possible allow for more accurate representation of variations in net load. This results in a more efficient use of reserves, because a larger proportion of VRE variability is absorbed by schedules and hence does not need to be balanced by reserves.

The shortest dispatch interval in major electricity markets today is five minutes, which is implemented by most independent system operators (ISOs) in the United States and in the Australian NEM. In most systems in the US (and indeed also the NEM), market operators procure balancing reserves centrally, co-optimised with energy in these shorter intervals. However, in Europe, most market operators procure reserves in day-ahead markets. The trade-off of procurement at the longer timescale is an increased certainty that the volumes of reserves are available, but at the cost of reducing the pool of available resources for energy in the intraday or real-time markets. Meanwhile, a shorter dispatch interval reduces the amount of reserves for deviations in the forecasts. This is demonstrated in Figure 15, where the increased trading of 15-minute products in the German intraday electricity market has led to a decline in the real-time deviations which have to be met by balancing reserves.

Figure 15 Effect of quarter-hourly trading on the need for reserves in Germany, 2012-2017



Source: Based on IEA (2021), Secure Energy Transitions in the Power Sector.

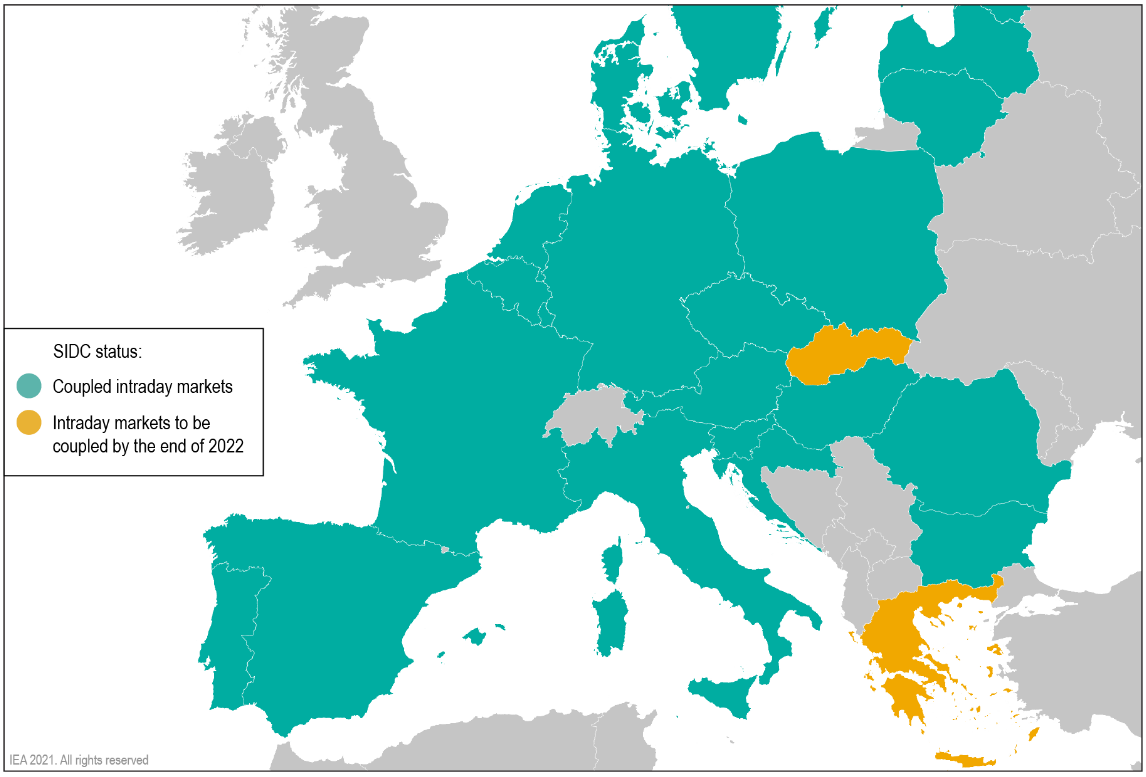
Regional integration of markets can provide system flexibility

As a country makes the transition to short-term electricity markets, there are risks of issues with market liquidity and price stability. However regional co-ordination of markets can help to mitigate these issues. Regional integration of markets is one option, although this may rely on a diverse set of trading partners. Moldova is currently largely reliant on imports from either Ukraine or Moldova GRES in Transnistria, which accounted for 81% of supply to the Moldovan system. While there are transmission lines connecting Moldova's electricity system to Romania, it cannot operate synchronously with Romania's electricity system (which is part of the Continental Europe Synchronous Area) as Moldova's electricity system is part of the Russian UPS. This is currently a large obstacle to wider regional integration of its markets. However, prior to the synchronous interconnection with Continental Europe, Moldova aims to connect asynchronously with Romania via HVDC back-to-back converters at several locations. This was a similar starting point for Lithuania which, as part of the BRELL (Belarus, Russia, Estonia, Latvia and Lithuania) group, is synchronously interconnected with the Russian UPS. Additionally, since the closure of the Ignalina nuclear plant in 2009, it has also become a net importer of electricity, with the majority of its demand met by imports (IEA, 2021c).

However, there may be key lessons to be learnt from the Lithuanian experience over the last 15 years, as it has progressively increased its diversity of trading partners for electricity through asynchronous interconnection with the Nordic Synchronous Area (via Sweden) and later with Continental Europe (via Poland). This then allowed for the coupling of its electricity market with the European market, in which it has since had its own price zone, and in which it has access to a suite of regional markets. This has resulted in a general decline of electricity prices in Lithuania due to the diversity of trade partners. It also increased the flexible portfolio to which Lithuania has access, allowing it to increase its portfolio of variable renewables and decrease its reliance on natural gas, for which it is completely reliant on Russian imports (IEA, 2021c).

As deployment of variable renewables accelerates, and markets have higher shares of wind and solar in their generation mix, the impact of the variability and uncertainty of VRE can be reduced by even further adaption of the short-term markets (intraday, balancing and ancillary services) by further expansion of balancing areas through inter-regional interconnectors, and allowing the use of imbalance netting and the exchange and sharing of reserves. An example of this has been implemented in the European electricity market, where the Single Intraday Coupling (SIDC) system has been deployed over multiple phases to allow for increased trading between participating countries following the closing of the day-ahead market. SIDC currently couples the intraday markets of 22 countries including the expansion of the products for cross-border trading to include 30- and 15-minute products across several borders (ENTSO-E, 2020). Amongst these 22 countries are neighbouring Romania and the nearby Baltic states (Estonia, Latvia and Lithuania).

Figure 16 The geographical scope and implementation phases of the Single Intraday Coupling (SIDC) in Continental Europe



Source: Based on data from All NEMO Committee (2021), Single Intraday Coupling.

Meanwhile, the Western Energy Imbalance Market (WEIM) in the western United States (hereafter "US") and Canada is one of the more innovative approaches to regional collaboration on real-time dispatch (IEA, 2019c). As a starting point, it is worth noting that it is the only regional market in the Western Interconnection in the US. Among the US states that make up the Western Electricity Coordinating Council (WECC), only California has introduced an independent system operator (ISO) – CAISO – meaning that the WEIM is the only wholesale market environment in the region, and even there the utilities remain vertically integrated.

The development of the WEIM, therefore, stands out from similar efforts elsewhere. In Europe, for example, efforts to develop regional balancing markets have followed the development of regional wholesale markets (e.g. Nord Pool) and wholesale market harmonisation more generally. The WEIM, in contrast, starts from the balancing side first, where it operates 15-minute and 5-minute real-time dispatch markets. Between its inception in 2014 and the end of 2019, it is estimated that the WEIM led to gross economic benefits of more than USD 860 million for participating due to more efficient dispatch, while also reducing 4.3 Mt CO_2 in emissions from the reduction in curtailment of renewables (IEA, 2021b).

Market design can evolve to better value flexibility

As VRE shares grow in systems around the world, the necessity for flexibility from a number of different resources, including power plants, storage, demand-side response and the grid, will increase. Power plants will be required to transition towards more flexible modes of operation and, at times, reduced operating hours. While existing power plants may offer increasingly important flexibility services to the power system, reductions in energy sales are leading to concerns about their financial viability, calling for the need to re-evaluate how they are compensated in many markets. This is equally important for storage and demand-side response, which can offer a range of flexibility services with the appropriate markets and incentives in place that value this flexibility. Storage, for example, in many wholesale markets is limited to energy arbitrage. However, with appropriate markets in place that value flexibility, storage can provide multiple services (e.g. balancing, ancillary services, congestion management, etc.) while combining these revenues (i.e. revenue stacking) can allow these projects to become profitable for developers. However, in their absence, a market may lack the appropriate incentives to ensure investment in flexible resources in a timely manner and also be unable to prevent early retirement of non-profitable power plants as the shares of VRE increase.

Reliable operation of the power system critically depends on a number of system services which contribute to maintaining system frequency and voltage levels. Special capabilities may also be required when restarting the system after a large-scale blackout (so-called black-start capabilities). Different systems may obtain the same service in different ways. For example, some will mandate it in the grid code, while others use a procurement or market mechanism.

As the penetration of VRE increases to very high shares, the need and economic value for such services are bound to change. One reason behind this is that conventional generators have traditionally provided many of these services as a simple by-product of power generation. For example, a conventional generator contributes to voltage and frequency stability with its voltage regulator and governor, including the inertia stored in the rotating mass of its turbine and generator.

While VRE plants are often seen as a driver for flexibility requirements and system services, they can also provide a range of system services, though this requires adequate technical requirements (e.g. grid connection codes) and, in some cases, economic incentives (e.g. markets) to explicitly procure services, such as fast frequency response and upward reserves, that enable the full range of their technical capabilities.

Islanded systems that are advanced in their own energy transitions have become good test beds for reforms in market design and system operation that mitigate system integration challenges as they have very little or no synchronous interconnection with other systems. For example, the all-island system of Ireland and Northern Ireland, the DS3 programme was introduced which has expanded the system services market to allow for the more instantaneous amounts of non-synchronous generation. The programme started a consultation process on a range of new system service products to address and mitigate potential system issues, which had been identified by comprehensive technical studies. New products have been proposed to address the challenges associated with frequency control and voltage control in a power system with high levels of variable, non-synchronous generation (EirGrid/SONI, 2021). The new services identified under the DS3 programme include synchronous inertial response, fast frequency response, fast post-fault active power recovery and a ramping margin.

Integrating forecasting into power system operations provides visibility of VRE production

The ability of the aforementioned short-term electricity markets (including closer to real-time dispatch) to provide flexibility hinges on the ability of system and market operators to properly represent wind and solar generation in their operation decisions. This is enabled through advanced forecasting which can accurately predict wind speed and solar irradiance, and subsequently forecast outputs from VRE plants on a sub-hourly basis.

Centralised system-level forecasting of VRE generation can greatly improve system operation by enabling the SO to account for overall variability of VRE outputs across the whole system and accurately predict the amount of VRE generation available. Forecasting is a useful tool to assist real-time dispatch, scheduling and operational planning.

In self-dispatching markets, forecasting of VRE generation helps generators to establish reliable schedules and limit schedule deviations. A good plant-level forecast will allow for a more cost-effective and reliable schedule of generation. A good system-wide forecast is critical in verifying that generation schedules are feasible and that sufficient operating reserves are held. Forecasts are regularly updated and are more accurate closer to real time. As the share of VRE increases, forecasting becomes an even more integral element of power system planning and operation.

One way to ensure that SOs have the ability to both control and monitor VRE production is through the establishment of renewable control centres. In 2006, Red Eléctrica de España (REE) in Spain was a pioneer when it established a Control Centre of Renewable Energies (CECRE), an initiative which allowed the SO to monitor and control renewable generation with real-time information. This also extended beyond just active power as it included reactive power as well as the voltage at the point of connection.

This same structure has since been emulated by numerous systems around the world. For example, in support of its growing share of VRE generation and its ambitious target of 175 GW by 2022, India inaugurated 11 Renewable Energy Management Centres (REMCs) in March 2020 which are co-located in the state dispatch centres in seven renewable-rich states (Gujarat, Rajasthan, Madhya Pradesh, Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu), in addition to being co-located in three of the five regional dispatch centres (north, west and south) and the national dispatch centre. The purpose the REMCs is to facilitate VRE integration along the Green Energy Corridors, a project started in 2013 to establish grid infrastructure to connect renewable-rich states and enable intra- and inter-state transmission (IEA, 2020e).

With the right policy, market and regulatory conditions in place, VRE can provide valuable system flexibility services

As VRE shares have grown, market operators have begun to take advantage of advanced forecasting to actively manage VRE in the dispatch. If VRE plants can automatically adjust their generation set point in response to control signals, the opportunity to provide frequency regulation services is opened. So, while VRE is often perceived as the key driver of new flexibility requirements, these plants can also provide flexibility services to address a range of operational issues related to power systems.

However, in order to enable this, system operators need to first define technical requirements for these services, in addition to appropriate economic incentives in many cases. For example, grid connection codes can explicitly stipulate certain services to be provided or to increase the visibility and controllability of VRE resources to system operators (IEA, 2019d). In addition, the provision of certain flexibility services may also require VRE generators to decrease their energy production, and hence their primary basis for remuneration. This may therefore require amendments to existing market frameworks or PPAs to allow for the fair remuneration of VRE resources for these services (IEA, 2019d).

For example, modern VRE resources which are controllable by the SO can provide downward reserves when operating at full output. However, if it were to run at a reduced output, it could also provide upward reserves by utilising the headroom between its reduced and full output. This mode of operation has been explored in a number of jurisdictions such as California, Chile and Puerto Rico (IEA, 2019d). Following these, the 141 MW Luz del Norte photovoltaic (PV) power plant from First Solar in Copiapó (Chile) became the world's first solar PV plant to be licensed to provide ancillary services, including frequency control, to the system operator in August 2020 (First Solar, 2020).

Key policies for ensuring that electricity markets promote flexible operation

Key overarching principles:

- New market design and market rules should be developed with a view to foster closer co-ordination and coupling with neighbouring markets in Ukraine and Romania to provide better liquidity and stability.
- Increased regional interconnection and diversity of trade partners would increase the potential for deployment of wind and solar.
- Further revision to market design should be in place to extend the short-term market to include real-time balancing and ancillary services on a regional basis to appropriately value and incentivise electricity generation and flexibility from all technologies at different times and locations
- As shares of VRE increase, system operation protocols should be updated to shorten dispatch intervals in order to reduce balancing requirements.
- The SO should have the capability to control and monitor VRE through advanced forecasting tools.
- Regional co-ordination of forecasting could help better highlight opportunities for trade of VRE amongst neighbouring systems in Romania and Ukraine.
- Network codes should require technical flexibility from VRE and conventional plants.

Specific policies and actions for consideration

Public-private stakeholder engagement

The Government of Moldova should develop a communication strategy and initiate dialogue between the public and private sectors for the development of fair, optimal and mutually agreed electricity markets and enabling environments.

System operation should enable flexibility

The SO should incorporate advanced forecasting tools and monitoring of renewable plants into system operations in order to allow for an accurate account of availability of plant outputs in both system and market operations.

The SO should look to minimise balancing requirements through the establishment of shorter dispatch intervals which, in combination with advanced forecasting of wind and solar generation, can reduce the balancing needs of the system.

Policymakers and the SO should explore the possibility of enhanced regional co-ordination with the neighbouring systems of Romania and Ukraine by sharing information from centralised forecasting and monitoring systems for VRE to allow for more optimal co-ordination of system and market operations in response to renewables over a large geographical area, accessing potential benefits in terms of smoothening variability and reducing imbalances.

Regional markets are needed that incentivise flexibility

The Government of Moldova should take the necessary steps to enhance cross-border trade with Romania and Ukraine. By diversifying the routes of electricity supply, Moldova can enhance electricity security and improve its negotiation position for the supply of power from Moldova GRES. This includes the development of regional infrastructure, harmonisation of cross-border trading rules and regulations, and the development of market rules with an aim towards the coupling of electricity markets in the region. Successful implementation and operation of the wholesale market will require liquidity, through the maximum participation of domestic and cross-border resources. Thus, there should be an aim to reduce the volumes traded by means of bilateral contracts.

The Government of Moldova should develop a short-to-medium- and long-term strategy towards synchronisation with the Continental Europe Synchronous Area. In the short- to medium-term, this should include taking the necessary steps to couple its electricity market with the European market via an asynchronous interconnection with Romania. However, in the longer term, considering the importance of Ukraine to the Moldovan system, this should include enhanced dialogue with Ukraine to develop a detailed roadmap towards the synchronisation of their interconnected systems with the Continental Europe Synchronous Area.

Policymakers and regulators should ensure that price signals indicate the value of electricity generation and flexibility in different locations and at different times, thereby ensuring that the market is able to provide clear investment signals for new generation or flexibility requirements (either domestic or cross-border) and the opportunity for participation from all technologies, including generation, storage and distributed energy resources. The latter includes distributed generation, demand-side participation and distributed storage.

Policymakers should promulgate rules that allow VRE resources to provide flexibility services, including reserves. VRE resources are technically capable of contributing to the reserves of a power system, but infrequently do so due to a lack of regulatory requirements or economic incentives. Allowing VRE to contribute to reserves can help unlock these resources as important contributors to system flexibility, but may require the introduction of a compensation scheme or regulatory requirement for VRE.

Enhancing technical flexibility of power systems

There are four key categories of infrastructure assets that provide system flexibility: (a) power plants (both conventional and VRE); (b) electricity networks; (c) energy storage; and (d) demand-side response (DSR).

Historically, conventional power plants, pumped storage hydro (PSH) and electricity networks have been the primary providers of flexibility (IEA, 2019d). However, due to declining costs and improving capabilities of newer technologies, such as battery energy storage systems (BESS) and the advent of distributed energy resources (DERs)[2], as well as the improvement of operational protocols, a wider range of flexibility options are now available.

[2] DERs include, amongst others, distributed generation, distributed battery storage, DSR and EVs

As power systems moved towards higher shares of VRE, these different technologies can work together to enhance the flexibility of the power system in a cost-effective manner. However, achieving this goal typically requires changes to policy, market and regulatory frameworks (IEA, 2019d). The following section brings together a few key examples which could be considered to make the Moldovan electricity system more flexible for higher shares of VRE, and for the potential transformation of the Moldovan electricity sector to one that is cleaner, more sustainable and more secure.

International best practices in increasing power system flexibility

Conventional power plants play a critical role in enhancing system flexibility

Conventional power plants are still currently the predominant source of system flexibility being used to accommodate the variability and uncertainty in supply and demand in modern power systems (IEA, 2019a). Flexible power plants can provide flexibility in a number ways, such as being able to rapidly change its output, starting up or stopping quickly and for short periods, and being able to reduce output without requiring a shutdown. There are a number of strategies to increase the flexibility that power plants provide to the system, ranging from modification of operational protocols to access inherent flexibility, to retrofits which improve technical parameters of these plants.

By modifying the operational practices of power plants, increased flexibility can be accessed without the need for new capital investments. However, this may need to be enabled by a better understanding of the operational limits of individual power plants through increased data collection and real-time monitoring (IEA, 2019a).

Meanwhile, the flexibility of power plants can be improved through targeted retrofits to achieve more flexible operation or pairing with other technologies such as BESS. For instance, the strategic coupling of BESS with existing plants is increasingly becoming a viable means of boosting flexibility, in both technical and economic terms. An example of the latter is Southern California Edison’s Center Peaker plant in Norwalk, California, where an existing gas peaking plant was coupled with a short-duration (< 1 hour) BESS. This has allowed the plant to provide spinning reserves without burning any fuel, while also offering valuable frequency response services. This is achieved as the BESS component of the hybridised power plant covers the spinning reserve requirements during the first few minutes as the gas plant would be required to start-up, after which the plant can ramp up to full capacity while the battery output decreases (IEA, 2019a).

Flexible and cleaner cogeneration

Cogeneration plants can be a highly restrictive constraint on the short-term flexibility of electricity systems, such as that in Moldova. In systems where cogeneration plants are used for combined heat and power, the generation of the plant is determined by the heat requirements. Hence, the plant will be designated as must-run. Decoupling heat and electricity provision via the introduction of heat storage or electric boilers can be used to overcome this. In some cases, for example the supply of district heating, the heat capacity of the network and connected buildings may be sufficient to ensure some heat and electricity decoupling.

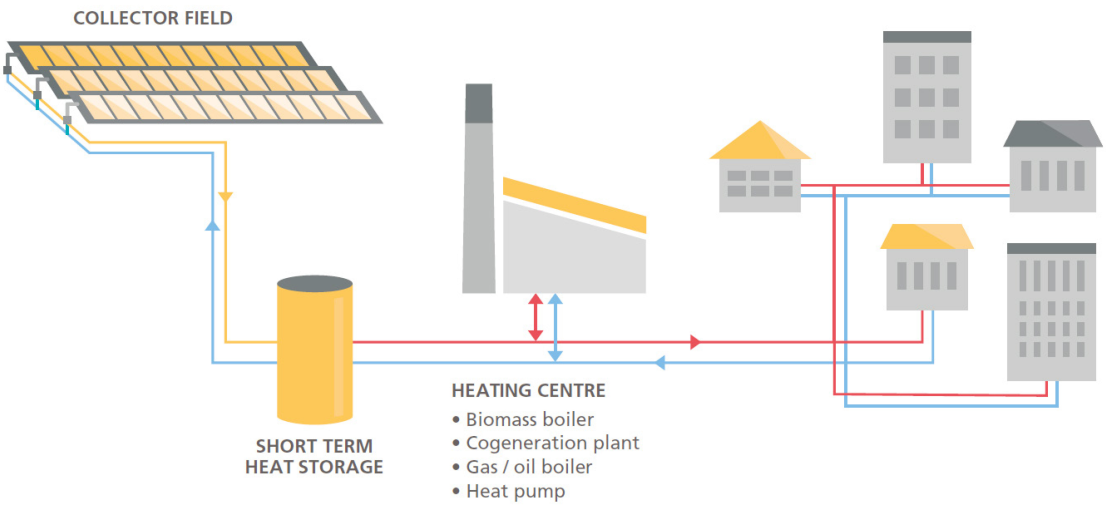
Several projects have been undertaken in Europe to make cogeneration plants more flexible as the share of VRE has increased. In 2015 Stadtwerke Kiel in Germany set out to replace a 50-year-old 323 MW coal-fired cogeneration plant. The original plant, with 323 MW of electrical output, was also able to provide 295 MJ/s of thermal energy to the city's district heating network (IEA, 2018). Meanwhile, the new installation, which was commissioned in January 2020, was deployed in two phases. The first phase consisted of a 30 000 cubic metre hot water storage facility, with 1 500 MWh capacity, a 35 MW electrode and a pump house to be connected to Kiel's district network.

During the second phase, twenty 9.5 MW gas engines were installed with a total capacity of 190 MW. The main requirement of the design was to be a secure power supply option in a system with a high VRE share. Deploying a large number of multiple units of gas-fired engines in cogeneration mode allows for units to always run at full load and maximum efficiency, with the number of units that run depending on heat demand. Meanwhile, the electric boiler commissioned in the first phase allows 35 MW of flexible heat storage and production, which can utilise cheap wind and solar power when available while maintaining a portion of the heat demand.

Smaller CHP plants in Denmark have also decoupled electricity generation from heat output through electric boilers, allowing more flexible operation in the provision of peaking heat capacity while also providing ancillary services such as operational reserves. Short-term heat storage is a common feature of Denmark's district heating network which can provide short-term storage of approximately 12 hours of heat production at full load. This can allow the larger, baseload CHP plants to reduce power output during times of high VRE generation and increase output during other periods (Danish Energy Agency, 2017). Heat is typically stored in large insulated steel containers in which hot water rises to the top and cold water drops towards the bottom. It is this separation of hot and cold water which enables the efficient loading and unloading of hot water from the storage (IEA, 2017b).

CHP plants in Denmark have also moved towards using biofuels and municipal waste as an alternative to fossil fuels. They have provided the additional benefit of advancing their clean energy transition and diversifying resources away from imported fossil fuels, though Denmark has now become a large importer of wooden pellets (IEA, 2017b). This, however, is not the only way of accessing clean and flexible district heating solutions. Denmark has also implemented a number of solar heating installations and solar district heating (SDH) networks, which may also be equipped with seasonal pit heat storage that allows solar power in the summer to be stored and used for heating in the winter (Epp, 2019). Large seasonal storages are implemented as underground storages in dams, aquifers, boreholes or caverns. This includes the re-purposing of old and abandoned infrastructure, e.g. old oil storage caverns (IEA, 2017b). In Denmark, over 1 GW of capacity for solar heating was connected to their network in 2019. It provides heat to 113 villages, towns and cities. A typical solar heating installation is depicted in 7.

Figure 17 Example of a typical solar district heating network with short-term storage



Source: IEA SHC - Technology Collaboration Programme (2019), *Solar Heat for Cities*.

Battery energy storage systems are becoming a cost-competitive flexibility provider

While PSH is still the most widely deployed utility-scale storage option with over 90% of global energy storage capacity (with 160 GW of capacity in 2019), a rapid decline in technology costs is creating an important opportunity for BESS to play a larger role in providing power system flexibility. A BESS offers notably fast and accurate response times to dispatch signals from system operators, and its modularity enables a wide range of installation sizes and potential locations for deployment. This differs from the more traditional storage options such as PSH which have been constrained by geographical limitations for suitable pumped storage sites.

Though battery costs have declined considerably,[3] in most contexts BESS are not yet a fully cost-competitive flexibility resource. While further reducing costs and improving the technology's performance characteristics remain important, it is equally important to ensure that policy, market and regulatory frameworks allow BESS to participate fairly within the power sector, and offer the full range of services they are technically capable of providing.

Battery storage systems are well-suited to short-duration storage that involves charging and discharging over a span of hours or days. This makes them a good partner for variable renewables, and there is a growing trend for battery storage to be paired with solar PV and wind. From an RE developer's point of view, BESS may be co-located with renewable projects in order to shift generation from periods of high supply (and low market value) to peak periods when generation is more valuable. Similarly, they may also be deployed as standalone projects, to provide energy arbitrage and offer an alternative to other peaking capacity such as gas turbines. Both of these applications would require a BESS with sufficient storage volume to provide capacity over the peak period, which would usually mean a storage duration of approximately four hours. An example of this is a recently completed tender for 1 200 MW of renewable projects with storage in India, which will lead to the installation of 600 MW of battery storage with five hours storage duration to provide firm supply to the Indian system (The Economic Times, 2020).

Furthermore, BESS can also provide vital system services. This however requires that they be able to bid into ancillary service markets to make them suitably attractive for developers. In most jurisdictions, to be cost-effective a BESS

[3] A 2019 report by Bloomberg New Energy Finance suggests that the levelised cost of electricity from lithium-ion battery storage has dropped 76% since 2012. See: https://about.bnef.com/blog/battery-powers-latest-plunge-costs-threatens-coal-gas/.

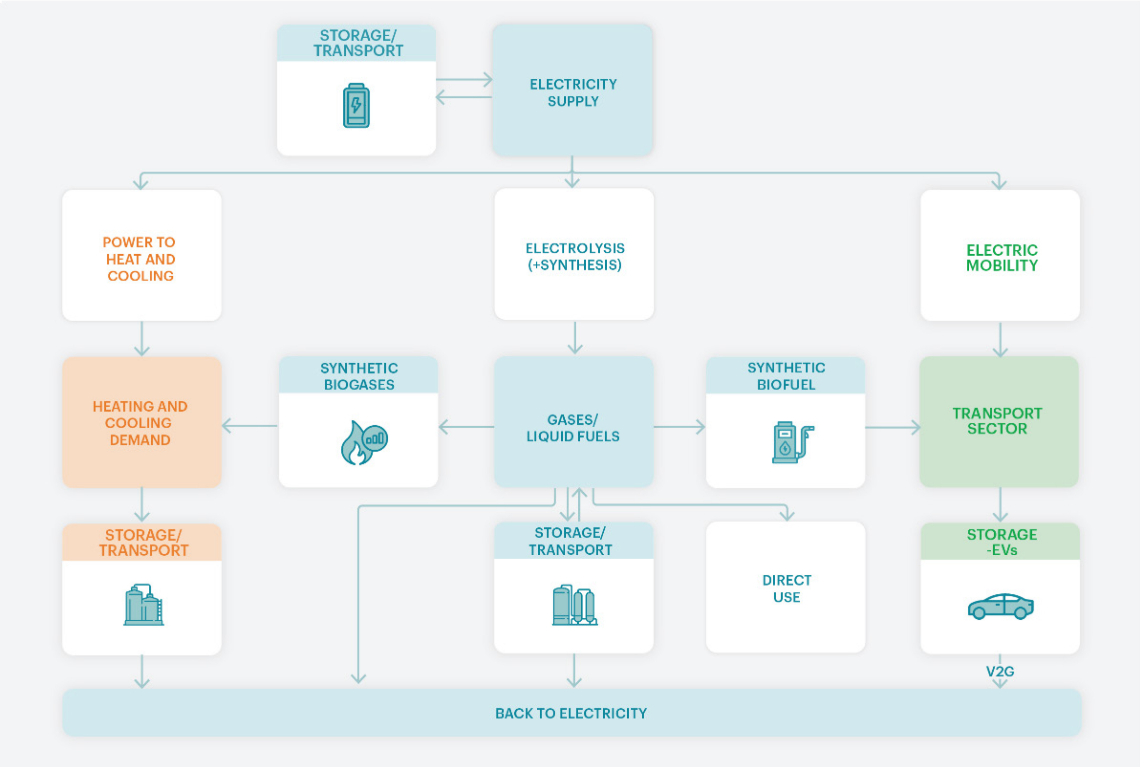
currently would need to combine multiple revenue streams, driven by the broad range of services it can provide. This would challenge existing policy, market and regulatory frameworks. However, if owned and operated by a TSO, several benefits could be realised without markets with revenue streams, and therefore provide a vision of how a BESS could be operated with the appropriate markets and incentives in place. An example of this in South Australia, where the 30 MW ECRIS-SA BESS is owned by ElectraNet, the DSO, but is leased to AGL, a large generation company. As a result, the BESS is able to provide regulated services such as reduced unserved energy and fast frequency response (for which no market currently exists in Australia), while AGL is able earn revenue through energy arbitrage and providing ancillary services through competitive markets (ElectraNet, 2020).

As VRE deployment accelerates, new flexibility requirements emerge and novel system services are created, the precision and speed of response from a BESS not only make it well-suited to providing these services, but it can also be the most cost-competitive when doing so. A prominent example is the recent auction for a new type of system service in Italy, an ultra-fast frequency regulation service or “Fast Reserve”, which aims to address stability challenges as the share of inverter-based generation increases in the system (Terna, 2020). Providers for this service were procured via a technology-neutral auction mechanism in a highly competitive auction, where 250 MW of BESS (comprising the entire auction) were awarded contracts to provide the service (Renewables Now, 2020). This follows the trend from a similar auction result in the UK a comparable service (Enhanced Frequency Response), for which the National Grid procured 201 MW of BESS in a competitive auction (KPMG, 2016).

Electrification of new flexible loads at scale has the potential to enhance power system flexibility

“Sector coupling” has been identified as a key strategy to promote economy-wide decarbonisation and broader macro-economic efficiency. It is defined as the intelligent linkage between the power sector and other energy-consuming sectors (e.g. industry, mobility and buildings), often through advanced sensing, communication and control technologies, that flexibly utilise demand to integrate VRE and reduce power system operational costs (IEA, 2019a). Sector coupling offers a significantly increased potential to reduce primary energy demand (through efficiencies and fuel switching) and increase flexibility of the demand-side of the power system, while also supporting power sector revenue sufficiency through electrification efforts which increase demand (Figure 18).

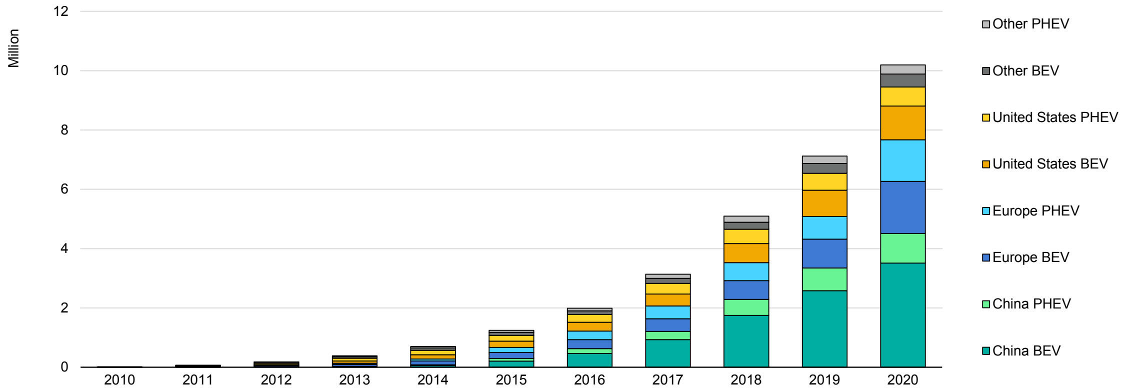
Figure 18 Conceptual diagram of sector coupling



Source: IEA (2019), *Status of Power System Transformation 2019*.

EVs provide a very good example of a newly electrified load. Europe is seeing a rise in personal cars and electric buses being deployed. As of 2020, there were 3.2 million BEVs in Europe, a rise from less than ten thousand in 2010. Globally, the stock of electric vehicles grew by 43% compared to 2019, with the number of vehicles exceeding 10 million vehicles by the end of 2020, and with BEVs representing two thirds of that total (IEA, 2021d). While the number of EVs is currently low in in Moldova, the Energy Community has started to consider the implementation of a revised Renewable Energy Directive (RED II) that, if fully transposed into Moldovan law, would set a target of 9% of renewable sources in the transport sector in Moldova by 2030.

Figure 19 Global electric car stock, 2010-2020

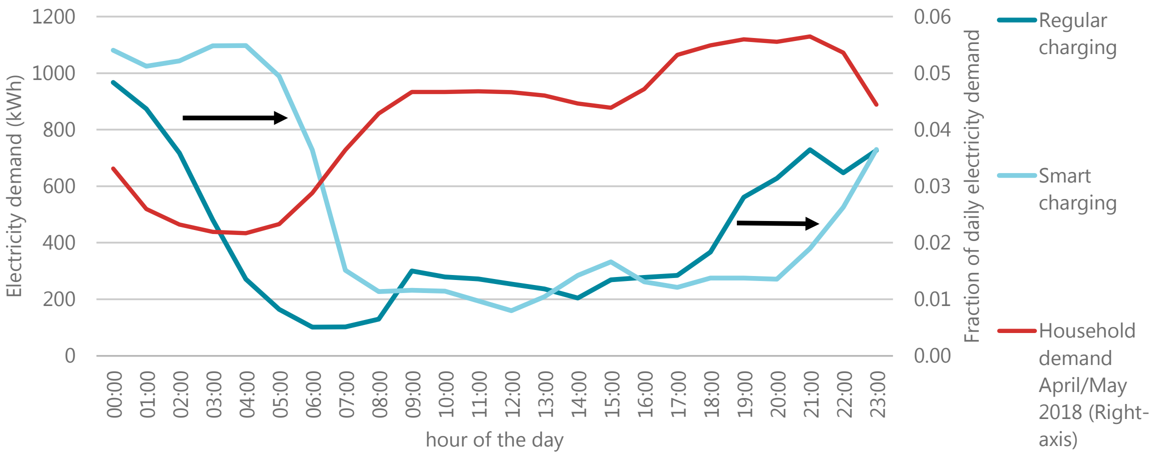


Source: IEA (2021d), *Global EV Outlook 2021*.

Under a normal charging pattern, EVs may be expected to add to the peak demand requirements of electricity systems as charging patterns would follow the commuting patterns of drivers, with considerable charging expected when people return home from work, contributing to evening peaks. However, the potential for smart charging of EVs could add considerable demand-side flexibility into modern and future power systems alike. This can be in the form of either time-of-use rates or smart/controlled charging (V1G), with both currently being explored for applications in cities around the world. Looking even further into the future, deploying vehicle-to-grid (V2G) technologies could then allow EVs to both consume electricity and act as a generator, like a battery, and therefore contribute to peak demand (IEA, 2020d).

An example of smart charging has been demonstrated in the Netherlands, where 1 000 EV charging sessions were pooled by an aggregator, Jedlix, and allowed to shift in response to price signals (IEA, 2019a). The resulting charging pattern showed a significant shift in charging (relative to 1 000 charging sessions which were not influenced by price) in order to take advantage of lower prices during off-peak hours. The charging pattern also shifted to periods of low household demand, demonstrating its potential benefit for alleviating local congestion on distribution networks. Based on existing usage patterns in the Netherlands, there is also significant potential for the use of smart charging. At the time of the study, the majority of charging in the Netherlands (30-50% nationally) occurred during the evening peak period, while cars were parked four-times longer than the required charging time (IEA, 2019a).

Figure 20 Regular and smart EV charging patterns from 1 000 simultaneous sessions compared with average hourly household demand in the Netherlands



Source: IEA (2019d), *Global EV Outlook 2019*.

Alternatives to new lines can help alleviate network congestion in the short term

Increased VRE penetration, particularly at locations where the grid is not strong, can exacerbate congestion in the network. Although congestion can have economic impacts, such as in the form of possible curtailment, it can also pose risks to the reliability of the system. Multiple options exist that may solve the issue, including grid reinforcement, demand management, targeted generation or storage, but these may not be economically attractive.

Cost-effective options are available to strengthen weak spots and better utilise transmission capacity without large-scale grid reinforcement. Typical measures are dynamic line rating (DLR), flexible alternating current transmission system (FACTS) devices and phase shifters.

As an example, DLR has been used to great effect in a number of systems worldwide (e.g. Australia, Belgium, France, Spain, Ireland, the United Kingdom and United States) to increase the limits of power transmission on their network and reduce congestion. Typically, a transmission line is rated at a certain capacity to carry power. While the limits of a line may be due to other considerations on the network (e.g. contingency, stability limits), the capacity is usually constrained by line sag, which happens due to current-related temperature increase. The conventional approach for determining the capacity of transmission lines is based on the worst-case assumptions (low wind speed, high ambient temperature and high solar radiation) (IRENA, 2020). However, the DLR calculates the capacity of transmission lines close to real time by taking into account actual operating and ambient conditions instead of assuming a fixed or seasonal capacity, therefore unlocking extra capacity on the transmission network. This can also have a good correlation with VRE, especially wind, as high wind output would occur during favourable conditions for increased capacity due to the DLR.

Grid requirements for the integration of VRE can also be considered as part of the infrastructure that is already being planned for other reasons. For example, Moldova is currently considering back-to-back converter stations with Romania at several locations to allow for asynchronous interconnection and electricity trade with its neighbour. However, with the appropriate technology, converter stations can also act as a grid support devices, especially in weak parts of the grid where the development of VRE may be considered in the future. While a number of technologies exist for these converter stations, HVDC technology that use Voltage Source Converters (VSC) can offer several benefits to the grid for integration of VRE, including frequency and voltage support, increasing grid stability as well as being able to contribute to black starts (Korompili et al., 2016).

Key policies for improving the technical flexibility of the Moldovan electricity system

Key overarching principles

With appropriate changes to market, regulatory and operational frameworks, additional flexibility can be accessed from existing infrastructure (e.g. power plants, grids, interconnectors).

New technologies can provide system flexibility but require the appropriate market framework and incentives to enable their use.

More flexible and clean district heating networks, with the decoupling of electricity and heat generation and the replacement of fossil fuels with biomass, can aid the integration of variable renewables and advance the climate goals of Moldova.

Appropriate changes are needed to markets and regulations that enable the participation of distributed energy resources, including distributed generators, storage and demand-side response.

Procurement of new firm capacity and system services, including domestic reserve capacity, should be competitive (either market or auction-based) and allow the participation of all technologies on an equal basis, including more innovative solutions such as variable renewables plus storage.

Specific policies and actions for consideration

Encourage public-private dialogue and sharing of best practice

The relevant organisations should disseminate assessment results widely to ensure that power system stakeholders understand near- and long-term flexibility needs. Dissemination of accurate and high-quality data facilitates investment decisions and enables sound analysis by a broader community, including potential investors, academia, research organisations and other advisers to government decision makers.

Power system stakeholders should facilitate domestic capacity building through international learning and exchange. Many global best practices are emerging in the form of policy solutions, planning practices and decision support tools. Supporting international engagement for ministry, regulatory and utility staff can enhance human capacity and ensure that domestic stakeholders are working efficiently towards a common goal.

Policymakers should promote domestic analysis by facilitating data sharing and issuing public grants for clean energy research on system flexibility. They should also issue calls for proposals to allow the research and analysis community to directly answer their questions about promoting system flexibility. Analysis activities will not only serve to strengthen human, technical and institutional capacity, but also help inform policy priorities and the next steps for policymaking.

Power system planners should convene and participate in domestic and international workshops to share information on and discuss power system flexibility issues and opportunities. Workshops can help raise awareness of system flexibility issues, review analysis and assessment results, advance dialogue around the evolution of market structures, build local capacity and help enhance investment environments.

Policymakers should engage directly with power plant operators and original equipment manufacturers (OEMs) to discuss the future flexibility requirements of the power system. Such dialogue can help communicate policy objectives and power system transformation goals to the plant owners, highlight power plant flexibility as a potential avenue for performance and revenue improvement, help policymakers understand the requirements of plant operators, and inspire power plant flexibility retrofit concepts from the OEMs.

Incentivise a range of flexibility solutions

Policy makers and regulators need to ensure that flexible operation of power plants is appropriately incentivised, with appropriate price signals for investment in flexibility that take into account new operating assumptions.

Flexibility remuneration solutions must be adapted to the specific circumstances of each power system and its broader goals. In the case of Moldova, policymakers should ensure that there are appropriate incentives to make domestic CHP more flexible through the decoupling of electricity and heat.

Policymakers should assess whether, in the absence of appropriate market signals, it may be appropriate to offer direct financial incentives to encourage the investment in retrofits or new plants with highly flexible components. Paying an incremental incentive upfront may reduce the need for more expensive flexibility investments in the future.

Policymakers and regulators should ensure the removal of entry barriers for distributed resources as flexibility providers, such as the high transaction costs associated with “qualifying” these small-scale resources for market participation. They must ensure that the necessary qualification requirements allow participation from the full range of flexible resources, taking into account the limitations of each technology.

As part of new market rules, new legal or administrative frameworks should ensure that new actors such as aggregators can fully participate in the new energy and/or ancillary services markets.

Parties responsible for grid planning and investment should adopt advanced strategies to increase available grid capacity, boost system flexibility and reduce operational constraints placed on power plants. This can include targeted investment in new, multi-use technologies that allow for grid support including high-voltage transmission lines, distribution networks, digital control systems and certain network infrastructure components (e.g. VSC-HVDC converters).

The regulator and market operator must ensure that appropriate changes are implemented to various market rules to ensure that storage can act as both a wholesale buyer and seller of electricity, while avoiding any inappropriate charges for this double role (e.g. consumer tariffs).

Regulators and market operators should implement market rules and regulatory changes that enable benefit-stacking in battery storage deployment so that batteries can be used to their full potential. Measures may include removing exclusivity clauses in ancillary services contracts, changing the specifications of flexibility services to allow for participation in multiple services, or redefining the role of storage owners to allow their participation in additional markets.

Consistently re-evaluate system flexibility needs

Policymakers and regulators should mandate regularly planned system adequacy assessments to include technical flexibility assessments. Creating a regulatory requirement to ensure these exercises also includes a technical flexibility assessment which would help to ensure that system flexibility insights can be used to inform long-term planning exercises.

Policymakers should facilitate the creation and maintenance of a comprehensive system-wide flexibility inventory. Assembling a clear picture of options aimed at increasing system flexibility will help to ensure that planning exercises are informed by the best possible data on options for the future.

A three-step vision for the system integration of renewables in Moldova

This section provides a vision of a modern, clean and secure electricity system in three steps, outlining the economic, environmental and social benefits it could deliver. The roadmap to this vision is split into three different timeframes: short- (1-5 year), medium- (5-15 years) and long-term (>15 years). While each timeframe has its own individual targets that detail the key actions needed to deliver this vision, they all stop short of offering a concrete timeline.

Delivering the vision of sustainable and secure electricity for Moldova

In order to provide the necessary conditions to deliver this vision a key set of policies, programmes and initiatives need to be rolled out over the three different timeframe periods: short term (ST), medium term (MT), long term (LT).

POLICY AND STRATEGY	SUB-CATEGORY	PROPOSED TIMEFRAME ST	MT	LT
Formal government recognition of clean electricity, and specifically the deployment of wind and solar PV, as a priority for energy security	Removal of regulatory barriers and increasing attractiveness to investors	●		
Public-private consultations to better understand current barriers to entry and to make public aware of costs and benefits of transitioning to cleaner energy sources	Removal of regulatory barriers and increasing attractiveness to investors	●		
The implementation of unbundling and the establishment of a new wholesale market which enables and incentivises flexibility from a plethora of private and public utilities	Establishment of flexible electricity markets with enhanced regional co-ordination	●		
Development of a RE roadmap which assesses and revises current limits on RE deployment, outlines RE development zones, allowing a high-level overview of necessary reinforcement to the grid, a more co ordinated approach to zoning and land-sharing for RE, and better access to financing and a long-term plan for the development of the renewable sector.	Removal of regulatory barriers and increasing attractiveness to investors	●		
Integration of RE roadmap into a national integrated energy plan for both generation and transmission grid planning, to better mobilise funds for the short, medium and long-term development of the Moldovan power system.	Removal of regulatory barriers and increasing attractiveness to investors	●	●	●
Immediate measures to stimulate the renewable sector by removing inconsistent taxation, customs and administrative barriers for rezoning of land or land-sharing	Removal of regulatory barriers and increasing attractiveness to investors	●		
Development of the capacity for local banks to finance wind and solar projects	Removal of regulatory barriers and increasing attractiveness to investors	●		
Reduction of investment risks for private financing while avoiding market distortion through the use of market premiums (sliding or fixed) in long-term PPAs	Removal of regulatory barriers and increasing attractiveness to investors	●		
Roll-out advanced forecasting tools within the system operator that allow better representation of VRE in the operation of the electricity market and the minimisation of balancing requirements	Establishment of flexible electricity markets with enhanced regional co-ordination	●		

POLICY AND STRATEGY	SUB-CATEGORY	PROPOSED TIMEFRAME ST	MT	LT
Implement feasibility studies towards modern system operation including dispatch intervals close to real-time and revision of existing system operation protocols which may limit the visibility or controllability of plants by the system operator in order to unlock latent system flexibility	Establishment of flexible electricity markets with enhanced regional co-ordination	●	●	
Continued assessment of system flexibility requirements for timely deployment of low-hanging fruit for flexibility measures from a range of technical measures or further development of policy, market and regulatory interventions	Enhancing technical flexibility of power system		●	●
Ensure that there are appropriate incentives to make domestic CHP more flexible through the decoupling of electricity and heat	Enhancing technical flexibility of power system	●	●	
Open dialogue with neighbouring countries, including Romania and Ukraine, in order to organise the Moldovan electricity market in a consistent manner with a view towards enhanced market coupling	Establishment of flexible electricity markets with enhanced regional co-ordination	●		
Take the necessary steps enhance cross-border trade with Romania and Ukraine, diversifying routes of electricity supply, and improving the negotiation position for the supply of power from Moldova GRES. This includes the development of regional infrastructure, harmonisation of cross-border trading rules and regulations, and the development of market rules with an aim towards the coupling of electricity market.	Establishment of flexible electricity markets with enhanced regional co-ordination	●	●	●
Develop short-, medium and long-term strategies towards interconnection with Continental Europe, that appropriately hedges against the pace at which synchronisation can be achieved by both Moldova itself, but also Ukraine, whom Moldova will need to maintain trade of electricity and services	Establishment of flexible electricity markets with enhanced regional co-ordination	●	●	●

POLICY AND STRATEGY	SUB-CATEGORY	PROPOSED TIMEFRAME ST	MT	LT
Develop asynchronous interconnection capacity with Romania while taking the necessary steps to couple the Moldovan electricity market with the European market, in order to diversify electricity trade and allow trade of both energy and services from a broader range of partners.	Establishment of flexible electricity markets with enhanced regional co-ordination			
Develop closer co-ordination for the monitoring and sharing forecasts of VRE with neighbouring markets in order to enhance trade of RE and minimise balancing requirements	Establishment of flexible electricity markets with enhanced regional co-ordination			
Expand wholesale markets to include technology-neutral markets aimed at procuring necessary system services or firm capacity markets	Enhancing technical flexibility of power system			
Promote domestic analysis and research, including the participation in international workshops, to better understand power system flexibility challenges and the range of solution available.	Enhancing technical flexibility of power system			
Include cross-sectoral planning into system planning exercises to ensure appropriate infrastructure, policies and regulation are in place that allows for flexibility from new demand-side resources (e.g. EV targets).	Enhancing technical flexibility of power system			
Mandate regularly planned system adequacy assessments to include technical flexibility assessments to ensure that system flexibility insights can be used to inform long-term planning exercises.	Enhancing technical flexibility of power system			
Responsible parties should disseminate assessment results of system needs (including flexibility) widely to ensure that power system stakeholders understand near- and long-term needs, and ensure timely investment.	Enhancing technical flexibility of power system			
Adaption of grid connection codes and market pre-qualification criteria to allow a broader range of distributed energy resources including inter alia, VRE plants, battery storage and EVs, to provide system services.	Enhancing technical flexibility of power system			
Ensure that there is the necessary investment in upgrading the grid and existing power plants towards compliance with the necessary technical standards for synchronisation with ENTSO-E.	Enhancing technical flexibility of power system			

References

All NEMO Committee (2021), Single Intraday Coupling, www.nemo-committee.eu/sidc.

Danish Energy Agency (2017), *Regulation and Planning of District Heating in Denmark*, https://ens.dk/sites/ens.dk/files/Globalcooperation/regulation_and_planning_of_district_heating_in_denmark.pdf.

EirGrid/SONI (2021), Shaping Our Electricity Future. www.eirgridgroup.com/the-grid/shaping-our-electricity-f/.

ElectraNet (2020), About the Battery, www.escri-sa.com.au/about/.

Energy Community (2020), Modalities to Foster Use of Renewable Energy Sources in the Transport Sector by the Energy Community Contracting Parties, www.euneighbours.eu/en/east/stay-informed/publications/modalities-foster-use-renewable-energy-sources-transport-sector.

ENTSO-E (2020), SIDC: Expansion of 30 and 15 Minute Products and Revised Local Implementation Project 14 Go-Live, https://eepublicdownloads.entsoe.eu/clean-documents/Network codes documents/Implementation/cacm/201124_SIDC_Expansion_of_30_and_15_minute_products_LIP_14__press_release.pdf.

Epp, B. (2019), Seasonal pit heat storage: Cost benchmark of 30 EUR/m^3, Solar Thermal World, www.solarthermalworld.org/news/seasonal-pit-heat-storage-cost-benchmark-30-eurm3.

IEA (International Energy Agency) (2021a), *World Energy Balances 2021* (database), www.iea.org/statistics.

IEA (2021b) *Secure Energy Transitions in the Power Sector*, www.iea.org/reports/secure-energy-transitions-in-the-power-sector.

IEA (2021c), *Lithuania 2021: Energy Policy Review*, www.iea.org/reports/lithuania-2021.

IEA (2021d), *Global EV Outlook 2021*, IEA, www.iea.org/reports/global-ev-outlook-2021.

IEA (2020a), *Renewables 2020: Analysis and Forecast to 2025*, www.iea.org/reports/renewables-2020.

IEA (2020b), *World Energy Investment 2020*, www.iea.org/reports/world-energy-investment-2020.

IEA (2020c), *World Energy Outlook 2020*, www.iea.org/reports/world-energy-outlook-2020.

IEA (2020d), *Global EV Outlook 2020*, www.iea.org/reports/global-ev-outlook-2020.

IEA (2020e), *India 2020: Energy Policy Review*, www.iea.org/reports/india-2020.

IEA (2019a), *Status of Power System Transformation 2019*, www.iea.org/reports/status-of-power-system-transformation-2019.

IEA (2019b), *Renewables 2019*, www.iea.org/reports/renewables-2019.

IEA (2019c), *Integrating Power Systems across Borders*, www.iea.org/reports/integrating-power-systems-across-borders.

IEA (2019d), *Global EV Outlook 2019*, www.iea.org/reports/global-ev-outlook-2019.

IEA (2018), *Status of Power System Transformation 2018*, www.iea.org/reports/status-of-power-system-transformation-2018.

IEA (2017a), *Status of Power System Transformation 2017: System Integration and Local Grids*, www.iea.org/reports/status-of-power-system-transformation-2017.

IEA (2017b), E*nergy Policies of IEA Countries: Denmark 2017 Review*, www.iea.org/reports/energy-policies-of-iea-countries-denmark-2017-review.

IEA Solar Heating & Cooling -Technology Collaboration Programme (2019), Task 55, *Solar Heat for Cities*, https://task55.iea-shc.org/Data/Sites/1/publications/Solar-Heat-for-Cities--The-Sustainable-Solution-for-District-Heating.pdf.

IRENA (International Renewable Energy Agency) (2020), *Dynamic Line Rating: Innovation Landscape Brief*, www.irena.org/publications/2020/Jul/System-Operation-Innovation-Landscape-briefs.

IRENA (2019), *Renewables Readiness Assessment: Republic of Moldova*, www.irena.org/publications/2019/Feb/Renewables-Readiness-Assessment-Republic-of-Moldova.

Korompili, A., Wu Q., & Zhao H. (2016), "Review of VSC HVDC connection for offshore wind power integration", *Renewable and Sustainable Energy Reviews*, Vol. 59, pp. 1405–1414, https://doi.org/10.1016/j.rser.2016.01.064.

KPMG (2016), EFR tender results, https://assets.kpmg/content/dam/kpmg/uk/pdf/2016/10/kpmg-efr-tender-market-briefing-updated.pdf.

Moldelectrica (2021a), Indicatorii Tehnico-Economici, http://moldelectrica.md/ro/network/annual_report.

Moldelectrica (2021b), Surse Regenerabile de Energie [Renewable Energy Sources], www.moldelectrica.md/ro/network/renewable_energy_sources.

Moldelectrica (2017), Plan de Dezvoltare a Rețelelor Electrice de Transport în Perioada Anilor 2018-2027 [Development plan for the electrical transmission networks in the period 2018-2027], www.moldelectrica.md/ro/network/perspective_plan.

Moldovagaz (2020), Datoriile regiunii transnistrene nu vor fi puse pe umerii consumatorilor din Republica Moldova [The debts of the Transnistrian region will not be put on the shoulders of the consumers in the Republic of Moldova], www.moldovagaz.md/rom/centrul-de-presa/mesajul-presedintelui/datoriile-regiunii-transnistrene-nu-vor-fi-puse-pe-umerii-consumatorilor-din-republica-moldova.

OECD (Organisation for Economic Co-operation and Development) (2020), *COVID-19 Crisis Response in Eastern Partner Countries*, www.oecd.org/coronavirus/policy-responses/covid-19-crisis-response-in-eu-eastern-partner-countries-7759afa3/.

Terna (2020), Fast Reserve – Information pack, www.terna.it/en/electric-system/pilot-projects-pursuant-arera-resolution-300-2017-reel/fast-reserve-pilot-project.

The Economic Times (2020), Greenko, ReNew win world's largest renewable-cum-storage based firm supply tender for 1.2 GW, https://economictimes.indiatimes.com/industry/energy/power/greenko-renew-win-worlds-largest-renewable-cum-storage-based-firm-supply-tender-for-1-2-gw/articleshow/73815236.cms.

Acknowledgements

This roadmap was written and produced by Craig Hart (Analyst – Renewable Integration and Secure Electricity), in co-operation with Talya Vatman (Policy Programme Manager, EU4Energy Programme). Markus Fager-Pintilä provided valuable data support.

The report also benefited from valuable inputs, comments and feedback from other experts within the IEA, including Rebecca Gaghen, Alejandro Hernandez, Edwin Haesen, Peerapat Vithayasrichareon, Jacques Warichet, Szilvia Doczi and Sebastian Papapanagiotou. Thanks go to the IEA Communications and Digital Office for their assistance in producing the roadmap, particularly to Therese Walsh, Isabelle Nonain-Semelin, Tanya Dyhin, Grace Gordon and Julie Puech. Elspeth Thomson carried editorial responsibility. LGND designed the visual brochure.

Special thanks goes to Mariana Botezatu, EU4Energy Country Expert for Moldova, for her in-country co-ordination and input. Valuable comments, feedback and input were provided by Alexandru Sandulescu (EU High-Level Adviser on Energy at the Ministry of Economy and Infrastructure), Denis Turmuruc and Nicolae Magdal (Ministry of Economy and Infrastructure). And a final thank you to the European Commission for their invaluable support for the IEA's work on EU4Energy.

This publication has been produced with the financial assistance of the European Union and is part of the EU4Energy programme. This publication reflects the views of the International Energy Agency (IEA) Secretariat but does not necessarily reflect those of individual IEA member countries or the European Union. The IEA makes no representation or warranty, express or implied, in respect to the publication's contents (including its completeness or accuracy) and shall not be responsible for any use of, or reliance on, the publication.

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Typeset in France by IEA - November 2021
Cover design: IEA (credit: Shutterstock)

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Co-funded by
the European Union