CENTER FOR THE STUDY OF DEMOCRACY

Low-Carbon Technologies

Roadmap for Deployment in Bulgaria by 2050

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DEMOCRACY

Renewable energy plays a key role in achieving Bulgaria's decarbonisation objectives. Yet their deployment *en masse* will require a seismic shift in how electricity is generated, distributed and stored. Despite the lack of consistent and transparent government support, the solar market is booming and Bulgaria will likely reach its 2030 renewable energy targets. However, frequent surplus solar photovoltaic generation is putting the grid off balance, and requires urgent policy actions to accommodate the further growth of renewables in the coming years. Bulgaria must capitalise on its offshore wind potential, enable decentralised electricity generation, modernise and upgrade the electricity grid, and promote the wide use of storage solutions. This calls for a strong vision that recognises the role of each technology in the decarbonisation process, based on clearly defined targets, policy and regulatory reform, financial incentives for investors, fair and transparent market conditions and strong support for the innovation ecosystem. The adoption of low-carbon cutting-edge technologies will drastically reduce emissions, while at the same time increase Bulgaria's energy independence, security of supply, and competitiveness.

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LIST OF ABBREVIATIONS

AI	Artificial Intelligence
CEC	Civil Energy Eommunities
BESS	Battery Energy Storage Systems
DSO	Distribution System Operator
EBRD	European Bank for Reconstruction and Development
ESS	Energy Storage System
EU	European Union
EWRC	Energy and Water Regulatory Commission
GHG	Greenhouse Gas
GW	Gigawatt
GWh	Gigawatt-hour
HPP	Hydropower Plant
LCOE	Levelized Cost of Electricity
MSP	Marine Spatial Planning
MW	Megawatt
MWh	Megawatt-hour
NECP	National Energy and Climate Plan
NRRP	National Recovery and Resilience Plan
PPA	Power Purchase Agreements
PPPs	Public Private Partnerships
PV	Photovoltaic
REC	Renewable Energy Communities
RED II	Renewable Energy Directive II
RED III	Renewable Energy Directive III
RES	Renewable Energy Sources
TJTP	Territorial Just Transition Plans
TSO	Transmission System Operator

EXECUTIVE SUMMARY

Bulgaria's national decarbonisation objectives are formally aligned with the broader EU targets, which include reducing greenhouse gas (GHG) emissions by at least 55% by 2030 compared to 1990 levels and achieving climate neutrality by 2050. According to the updated NECP, by 2030 **Bulgaria should achieve a 34.48% share of energy from renewable energy sources (RES)** in gross final energy consumption. For the electricity sector, this share is 55.51%. However, **the Plan does not propose concrete measures to deploy the cutting-edge technologies** and related policy options, necessary for achieving the climate neutrality goals, focusing instead on maintaining the use of fossil fuels for power generation, mostly coal, and on expanding the centralised large-scale nuclear power production.

In contrast with the EU's emphasis on decentralised power supply to promote energy independence and resilience, **Bulgaria's policy framework primarily enables utility-scale renewable energy plants**. This approach tends to concentrate market power in the hands of a few large entities, often linked to established state and private networks. Such concentration can exacerbate supply volatility, as large-scale plants are more susceptible to fluctuations in production due to their **reliance on specific geographic and climatic conditions**. Moreover, this model can stifle the growth of smaller, decentralised renewable energy projects, which are essential for the resilience of the power grid. As a result, Bulgaria fails to realise the potential benefits of a more democratised energy sector, such as increased local economic development, community engagement, and energy security.

Despite the lack of a robust and consistent regulatory framework, Bulgaria's energy sector has been enjoying an **exponential rise of new PV** capacity, expected to last at least until 2030. By then, up to 7 GW of solar could be connected to the grid. Although this surge will help Bulgaria achieve its national objective for renewable energy in gross final energy consumption by 2030, it has also led to or highlighted some **significant imbalances in the sector**. **Excess power has nowhere to be stored or directed**, especially after the breakdown of the Chaira pumped-storage hydropower plant, increasing the risk of supply disruptions. **Grid balancing will have to rely on decentralised solutions**, enabling grid operators to successfully manage the volatility and unpredictability of renewable generation, and stabilise the grid in periods of excess supply.

Bulgaria can activate nearly EUR 5 billion in EU funds from the Recovery and Resilience Facility, the Modernisation Fund, REPowerEU, the Just Transition Mechanism and the EU Structural Funds to boost investment in low-carbon technologies; by far the largest public investment pool ever available to the country. The package remains hostage to the country's toxic political polarisation and instability, which favours incumbent fossil fuel lobbies and seriously undermines Bulgaria's long-term competitiveness position vis-à-vis its immediate neighbours and the global technological frontier and supply chains. The growing backlash towards the European Green Deal

could seriously harm Bulgaria's technological modernisation and economic prosperity. Bulgaria lacks vision and political leadership to make use of the different readily available low-carbon technologies and to take concrete policy actions to **diversify Bulgaria's energy mix and facilitate the more secure, innovative, and efficient distribution and storage of the generated electricity.** Bulgaria's government could:

- unlock Bulgaria's **offshore wind energy** potential in the Black Sea by adopting an Offshore Renewable Energy Law and related regulations, upgrading the necessary port and electricity grid infrastructure and introducing transparent permitting procedures;

- enable **decentralised electricity generation** by implementing the RED III Directive, streamlining procedures for accessing the grid and providing policy and financial incentives for energy communities;

- **expand and modernise the power transmission and distribution grids,** and deploy digital solutions for metering and monitoring their performance.

- **integrate electricity storage systems (ESS)**, both in-front and behind-the-meter, in energy planning and develop market mechanisms to compensate for the full range of services provided by these technologies**.**

If these actions are taken consistently and transparently, by consecutive governments, Bulgaria will be able to: achieve full decarbonisation by 2050, reduce the costs linked to the coal phaseout, spur industrial revival and competitiveness, and generate private sector investments for faster and more cohesive growth.

INTRODUCTION

Europe aims to become the **first climate-neutral continent by 2050**, aiming for net-zero greenhouse gas (GHG) emissions, whilst promoting economic growth decoupled from resource exploitation and prioritising a fair, and inclusive transition for all regions. To address the **energy crisis exacerbated by Russia's invasion of Ukraine**, the EU accelerated the shift to renewable energy sources in order to reduce its dependence on Russian fossil fuel imports. The transition to renewables is therefore essential not only for climate change mitigation but also for reducing reliance on external energy supplies and achieving economic sustainability.

Bulgaria's climate goals are formally aligned with these EU objectives. The country aims to reduce GHG emissions by at least 55% by 2030 (relative to 1990 levels) and reach climate neutrality by 2050. The draft revised National Energy and Climate Plan (NECP) sets a target of 34.48% renewable energy share in total consumption by 2030, with a 55.51% share for electricity. However, **the NECP falls short in proposing modern technological solutions for climate neutrality**, relying heavily on fossil fuels and expanding nuclear capacity rather than deploying innovative low-carbon technologies.

In contrast to the EU's emphasis on decentralised power generation for energy independence, **Bulgaria's policies continue to favour large-scale renewable energy projects**. The result is the concentration of control in the hands of a few large entities, often linked to established networks with state and private interests.[1] This has also contributed to societal opposition against decarbonisation policies, as many Bulgarians view them as benefiting entrenched networks rather than the general public, especially given the sector's issues with corruption and lack of transparency. This erodes public trust and hinders essential reforms.[2]

The **2023 legislative changes** to the Energy Law and the Renewable Energy Sources Law tried to align Bulgaria's legal framework with the EU's Renewable Energy Directive (RED II), but **lacked sufficient transparency and analysis**. The amendments favour solar energy over wind, potentially limiting the development of Bulgaria's substantial onshore and offshore wind potential. Wind energy could play a crucial role in balancing renewable power when solar power generation is low, but regulatory hurdles and local-level social opposition continue to delay its expansion. They also do not provide enough clarity on energy communities, nor do they define the important role of grid modernisation or energy storage. As this analysis shows, developing the necessary policy and legal environment is a crucial first step for the large-scale deployment of low-carbon technologies.

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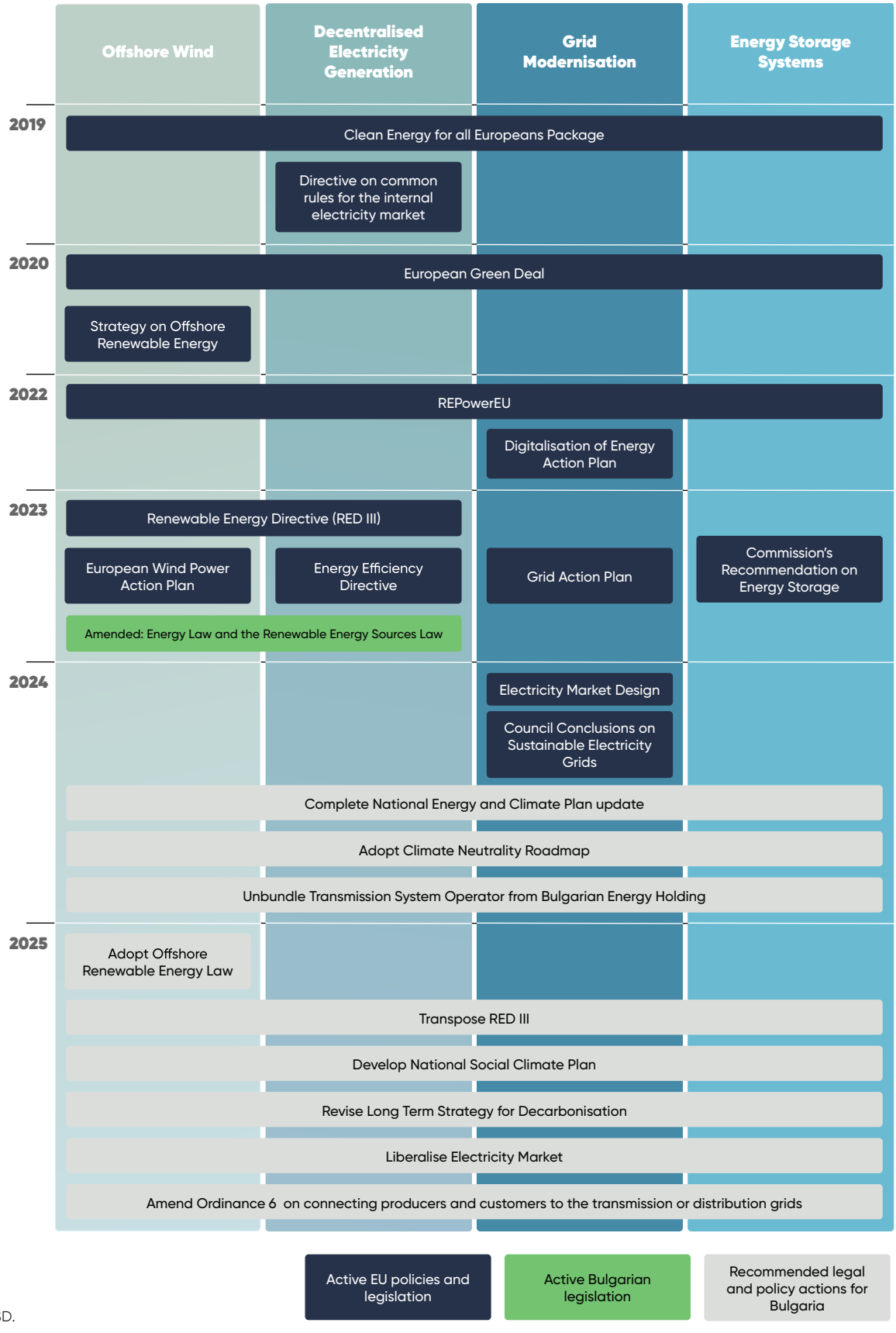
1 Galev, T., Gantcheva, N., Stefanov, R., Tsanov, M., Vladimirov, M., "Energy Sector Governance and Energy (In)Security in Bulgaria", Sofia, CSD: 2014

2 Green European Journal, Staykov, G., "Source of Division: Bulgaria's Contested Green Transition", 2023

Figure 1. To-do-list: Aligning the Bulgarian energy transition policy and regulatory framework with the aims of the European green deal



Source: CSD.

Key changes include completing the reforms under the National Recovery and Resilience Plan, liberalising the electricity market and adopting either dedicated legislation for the deployment of certain technologies (e.g. offshore wind), or amending existing national regulations to facilitate grid access for new renewable projects and storage facilities.

To achieve full decarbonisation by 2050, **Bulgaria needs a comprehensive strategy that integrates various low-carbon technologies into a unified energy management system**. This Roadmap outlines the necessary legal, policy, and technological milestones to reach these goals, focusing on overcoming national challenges, transforming the energy sector through targeted actions and accelerating the adoption of low-carbon technologies:

- offshore wind energy;
- decentralised electricity generation;
- grid modernisation;
- electricity storage systems.

OFFSHORE WIND ENERGY

The **European Green Deal** has emphasised the importance of increasing the use of renewable energy, including offshore wind, to achieve carbon neutrality by 2050. To achieve its 45% RES target, 440 GW of operational wind capacity will have to be installed in the EU by 2030, including a significant portion of offshore projects.[3] In 2023 alone, the European wind industry provided EUR 52.1 billion to the EU's GDP, **each new offshore wind turbine added EUR 27 million of value added** and 86% of all wind energy payments went to European companies, highlighting the enormous and growing potential of the sector, not only for decarbonisation efforts, but also to increase Europe' competitiveness.[4]

The 2023 **Renewable Energy Directive (RED III)**, aims to further this accelerated investment spree by simplifying administrative procedures, strengthening maritime spatial planning and promoting grid modernisation to accommodate the increased offshore wind capacity.[5] In 2020, the EU published its **Strategy on Offshore Renewable Energy**[6], which aims to increase Europe's offshore wind capacity to at least 60 GW by 2030 and 300 GW by 2050, and further elaborates the necessary steps to achieve these goals in the 2023 **European Wind Power Action Plan**[7]. Europe is a global leader in offshore wind energy, and some estimates suggest that the continent's projected future electricity demand cannot be met without the maximum deployment of offshore wind.[8]

Large-scale deployment of wind energy in the Bulgarian section of the Black Sea coast could strongly contribute towards the achievement of the country's energy transition objectives. **Offshore wind will stimulate low-carbon economic development, the uptake of competitive and secure energy production and the reduction of the country's dependence on fossil fuel imports**. This will help reduce carbon emissions from coal and natural gas-fired power plants and will also ease the burden on balancing the electricity system. Offshore wind power will improve energy security, **especially during peak demand, by reducing the need to use baseload generation that has a higher emission factor**. Despite the key role that offshore wind energy could play in Bulgaria's decarbonisation, the NECP only envisages a total installed capacity of offshore wind of 3.84 GW by 2050 in its most ambitious scenario[9], while the NRRP simply mentions the need to develop

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[3] Rystad Energy & WindEurope, The State of the European Wind Energy Supply Chain, April 2023.

[4] European Technology and Innovation Platform for Wind Energy, "European Wind Energy Competitiveness Report", June, 2024

[5] European Commission, Renewable Energy Directive, October 2023

[6] European Commission, An EU Strategy to harness the potential of offshore renewable energy for a climate neutral future, November 2020

[7] European Commission, European Wind Power Action Plan, October 2023

[8] Freeman, K. et. al., Our energy, our future: How offshore wind will help Europe go carbon-neutral. Swindon: BVG Associates Limited: 2019.

[9] Ministry of Environment and Waters, Draft National Energy and Climate Plan, June 2024

the regulatory environment[10], but neither provides any further analysis of the sector's potential or concrete measures to boost its development.

Bulgaria's technical potential for offshore wind in the Black Sea is approximately 116 GW, to be realised through 26 GW of mature bottom-fixed technology and 90 GW through floating power plants. Despite the higher cost of offshore wind compared to other renewables, the unit cost of electricity generated by bottom-anchored plants is in the range of EUR 90-100 per megawatt-hour (MWh), which is likely to be competitive with average electricity market prices over the next decade. During periods of peak demand, average day-ahead electricity prices have already reached EUR 90/MWh (and much higher during the actual peak hours). Annual average prices are forecast to be around EUR 70/MWh in 2025 and hover around EUR 85-90/MWh by 2030. Due to the considerable capital intensity of investments in floating installations in sea depths beyond 60m, the average cost per unit of energy produced is estimated to be in the range of EUR 120-158/MWh.[11]

Four areas have been identified as suitable for potential project development of offshore wind energy in the Bulgarian Black Sea exclusive economic zone. Full-load hours (the time needed to produce the total electricity under full load conditions of the generators) are calculated at a height of the rotor of 150 meters and increase both with water depth and distance from shore:

- **Area 1: Shabla/Romanian maritime border**: 30 km away from the seaside resort of Shabla, this area is the largest of the four and has the best wind resources.

- **Area 2: Varna**: the smallest area, but in the immediate proximity of Varna, an important economic centre with two industrial zones, an airport, and the biggest Bulgarian seaport. Offshore wind projects could be developed as part of a broader low-carbon industrial restructuring process as the most prospective offshore wind zones are located close to a major industrial power demand centre. Despite the large potential, only a small fraction could be utilised due to the intense marine traffic in the area and the various environmental protection and military training areas in the vicinity.

- **Area 3: Obzor**: a large area located about 30 km away from Burgas, the second largest town on the Black Sea coast in Bulgaria. Full deployment of its technical potential is limited due to conflicts with current navigation routes.

- **Area 4: Turkish maritime border**: the large area is far away from the Bulgarian shoreline but is close to a planned high-voltage DC submarine cable connecting Romania and Turkey. The site has potential for the development of floating-platform-based wind parks after 2030.[12]

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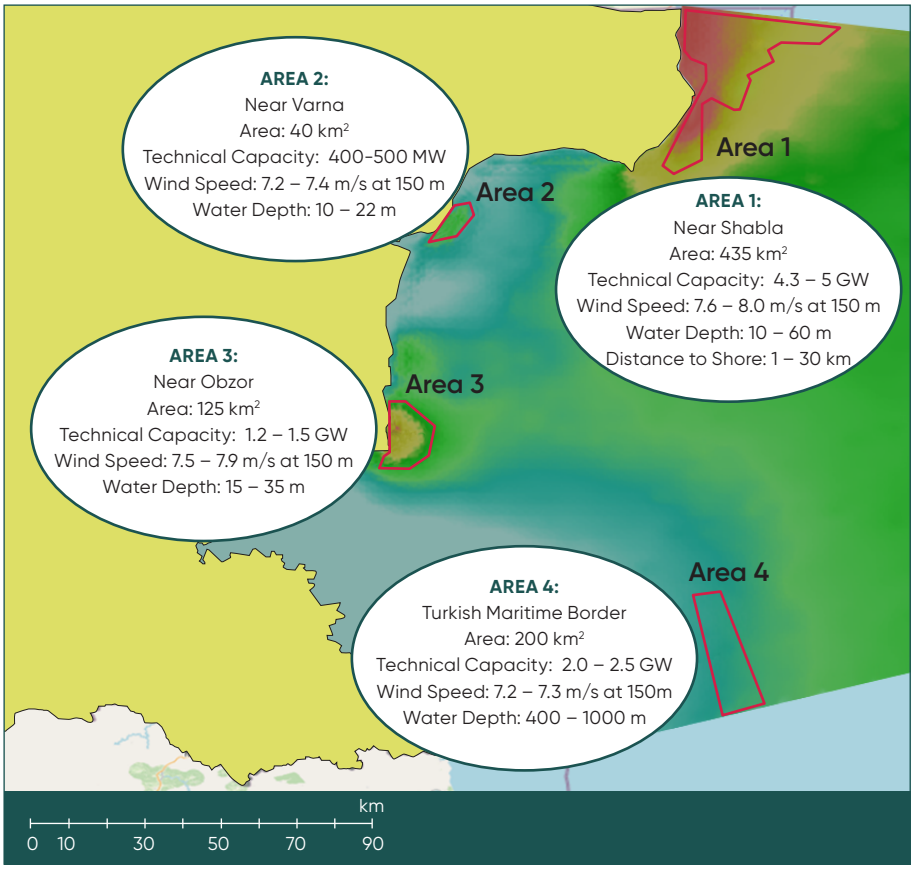
[10] Bulgarian National Recovery and Resilience Plan

[11] Trifonova, M., and Vladimirov, M., "Wind Power Generation in Bulgaria: Assessment of the Black Sea Offshore Potential", Sofia: CSD, 2021

[12] Trifonova, M., and Vladimirov, M., "Wind Power Generation in Bulgaria: Assessment of the Black Sea Offshore Potential", Sofia: CSD, 2021

Figure 2. Pre-selected prospective areas for the deployment of the offshore wind potential in Bulgaria



Source: CSD based on Global Wind Atlas data.[13]

Barriers to Deployment

Despite the significant potential for development, offshore wind energy faces several barriers, slowing down its deployment, the first being the lack of a **regulatory framework** based on transparent, consistent and competition-friendly principles and procedures. A dedicated **Offshore Renewable Energy Law** has been in the works since 2022 and has passed its first reading in Parliament with a two-thirds majority. However, pro-Russian lawmakers launched a campaign against it, organising protests and pressuring the unstable majority to delay adoption. Bulgaria's ongoing political instability complicates efforts to maintain broad political support for the initiative, which **requires consistent political will** and a long-term commitment to the sector.

The draft law was also met with **strong politically stoked public backlash** from representatives of tourism and fishing companies, as well as environmental organisations. They have been misled to believe that the construction of offshore wind parks in the Black Sea will lead to lower fishing yields, lower number of tourists and negative impacts on local fish and bird populations.

[13] Data obtained from the Global Wind Atlas 3.0, a free, web-based application developed, owned and operated by the Technical University of Denmark (DTU).

This has highlighted the **need to raise awareness about the many socio-economic benefits** of the industry and the available strategies to mitigate potential risks, thus countering disinformation efforts.[14]

A crucial part of the policy framework regulating the development and exploitation of offshore wind projects is their integration into **Marine Spatial Planning** (MSP) and the relevant **auctioning, permitting and licensing procedures**. Bulgaria's current 2023 MSP[15] only mentions offshore wind, but no official studies have been performed to assess how it can coexist with other marine economic activities. The draft Offshore Renewable Energy Law provides a framework for site-development models, but once it is adopted, relevant authorities will need to **streamline and simplify the existing time-consuming and administratively heavy procedures** for grid connection.

Another key prerequisite for the successful deployment of offshore wind projects is the access to key infrastructure, namely a **high-voltage transmission grid, and adequate port facilities and maintenance bases**. The Transmission System Operator (TSO) is planning on expanding and upgrading the transmission grid and existing substations to be able to accommodate new RES projects, which are often located away from the transmission grid. However, the **TSO also acknowledges that it cannot build new power lines and substations at the rate of construction of the RES**, which may hamper or delay the development of offshore wind projects, especially if solar projects competing for access to the same grid continue to receive preferential treatment.[16] On the other hand, while the **ports of Varna and Burgas** can support the delivery and shipment of cargo, they may need further expansion to serve as Operation and Maintenance bases for any future offshore wind parks.

Finally, Bulgaria's slow and **incomplete electricity market liberalisation has increased price volatility**, market liquidity, and regional integration, complicating price forecasts for renewable energy investors. Given the high upfront capital costs involved in technologically complex projects with longer return on investment periods, such as offshore wind farms, the **lack of predictability about revenues significantly increases borrowing costs.**

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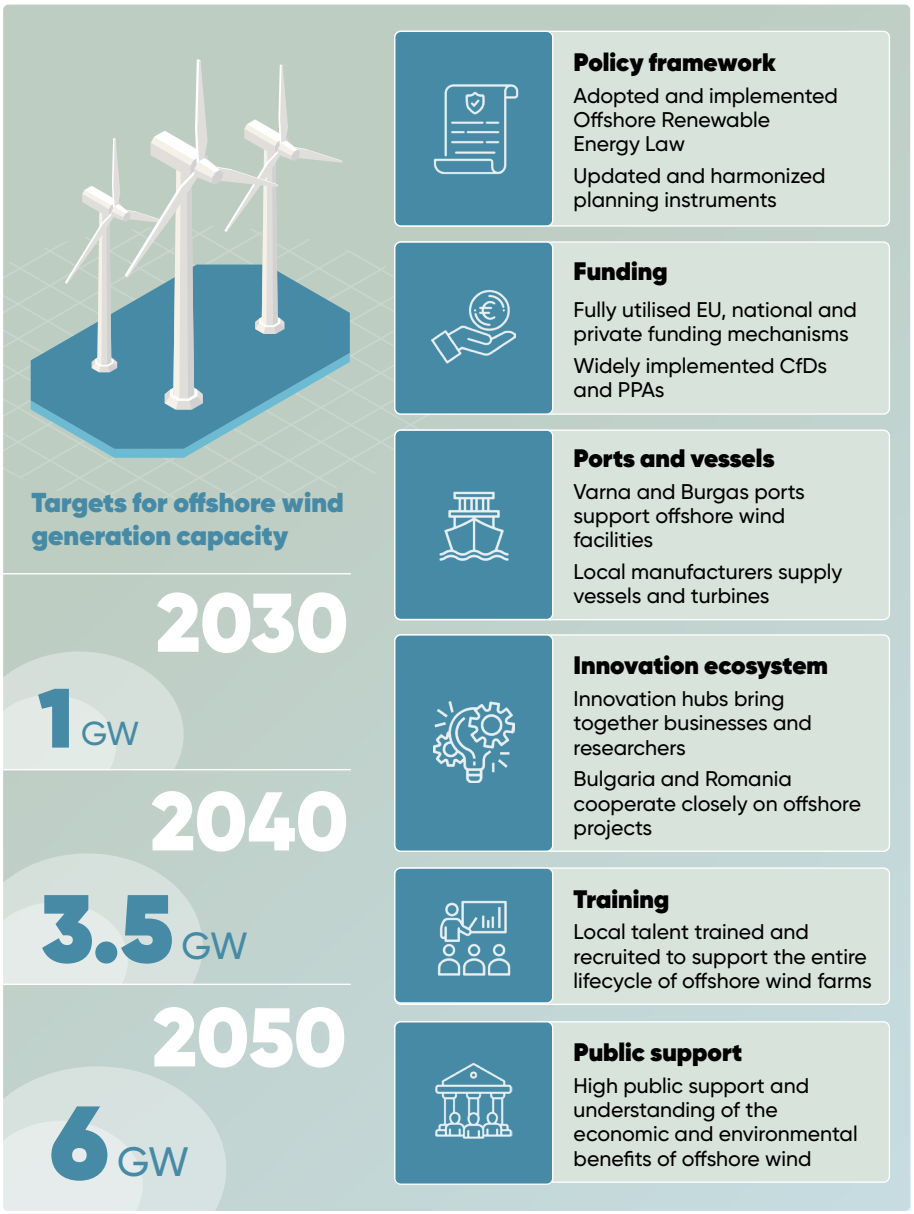
[14] Bulgarian National Television, "Fact check: is life dying after wind turbines and who is behind these claims?", February 2024

[15] Bulgarian Ministry of Regional Development and Public Works, Marine Spatial Plan, May, 2023

[16] Electricity System Operator, Draft Plan for the Development of Bulgaria's Electricity Transmission Grid for 2024-2033

Strategic Actions

Figure 3. Unleashing the offshore wind energy sector in Bulgaria



Source: CSD.

To overcome these barriers and achieve its long-term decarbonisation vision, the Bulgarian government must urgently **prioritise the development of offshore wind power** and not lag behind its neighbours in the region[17]. This requires a coordinated approach to develop and streamline the regulatory environment, introduce a variety of funding and power purchasing mechanisms, expand and upgrade port infrastructure, foster the local innovation ecosystem, work with neighbouring countries to develop common projects and build social acceptance both at the local and national levels.

[17] Greece and Romania have both recently adopted strategic documents and legislation supporting offshore wind and setting national targets.

The first crucial step towards enabling the development of the offshore wind industry and providing clarity and predictability to potential investors is to develop a **sound policy and regulatory framework.**

- **Adopt the draft Offshore Renewable Energy Law**: The adoption of a dedicated legislative framework will help streamline the development of offshore wind projects. It should plan auctions initially for areas with a minimum of 1 GW capacity until 2027 and and then another 2 GW by 2030, ensuring a basic level of market scale and steady growth.

- **Harmonise planning instruments**: Any government action in the sector should be based on evidence-based analysis of the offshore wind energy potential in national waters to align the realistic short, medium and long-term targets for new capacity additions, considering different constraints such as power transmission network limitations, conflicts with environmental zones, marine traffic routes and competing economic activities.[18] The analysis should be reflected in all relevant strategic documents, especially the Marine Spatial Plan, which should include a special section on offshore renewable energy and the Plan for the Development of Bulgaria's Electricity Transmission Grid, which should account for the necessary grid expansion to accommodate offshore projects, especially in Northeastern Bulgaria, where solar and onshore wind projects are also competing for grid access.

- **Fill outstanding regulatory gaps**: Project developers should have access to transparent information regarding the capacity at all grid connection points, and the TSO should establish a clear and publicly available methodology for assessing connection costs to provide certainty to investors. The Concession Law should be amended to avoid any potential conflicts over areas, which are already under concession, for example, for oil and gas exploration and production activities, but also have offshore wind potential.[19]

- **Sign the EU Wind Charter**: This commitment is crucial to align Bulgaria with the common European wind energy development targets. The Charter could be a platform, based on which Bulgaria can gain greater access to the sector's best practices and technologies, while also boosting investor confidence through the creation of a unified policy approach.

- **Set offshore wind deployment targets**: Bulgaria must set a national offshore wind energy deployment target to demonstrate its political commitment to the sector and attract investment interest in specific Black Sea deployment areas. The target should be included in the revised NECP and be linked to a detailed timeline with specific milestones, policy measures and funding mechanisms.

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[18] Arsani, A., Koeppen, M., Mikulcic, H., Siwinski, P., Vladimirov, M., "At the Frontier: Guidelines for Unlocking the Offshore Wind Energy Potential in Central and Eastern Europe", Sofia: CSD, 2024

[19] Trifonova, M., and Vladimirov, M., "Wind Power Generation in Bulgaria: Assessment of the Black Sea Offshore Potential", Sofia: CSD, 2021

- **Establish a one-stop shop authority**: The Offshore Renewable Energy Law should also clearly define the duties and responsibilities of all public authorities, which have specific relevant competencies related to offshore wind. To better coordinate all activities related to offshore wind projects and reduce bureaucratic hurdles for investors a cross-institutional authority should be appointed, for example as permanent advisory body of the Council of Ministers with dedicated administrative staff with relevant expertise to manage the different stages of each project.[20]

To expedite the development of commercial offshore wind projects, it is crucial to provide a wide range of **funding mechanisms** to demonstrate the country's commitment to the sector and attract private investors, whilst leveraging the available EU financial instruments aimed at decarbonisation.

- **Utilise EU and national financial instruments**: The Bulgarian government should leverage REPowerEU and other available EU financial resources to better prepare Bulgaria's coastal regions for accommodating offshore wind projects. This includes building administrative capacity of local authorities, upskilling local talent to multiply the economic impact of new projects and developing the local innovation ecosystem to help include Bulgarian companies in global supply chains.

- **Implement Contracts for Difference and PPAs:** Investors in offshore wind project should be attracted by introducing innovative financing models. Competitive auctions for the approval of Contracts for Difference (CfDs), managed by the Electricity System Security Fund, will ensure price stability and revenue predictability for investors, whilst driving down the projects' financial costs and stimulating large-scale investment. The auction aims to set a strike price in the concession agreement, ensuring revenue stability for power plant operators and helping them secure better loans. All electricity is sold on an exchange, with government compensation covering the difference between the market price on the Bulgarian power exchange, and the strike price.[21] Corporate long-term Power Purchase Agreements (PPAs) for offshore wind would provide an incentive for industrial consumers to secure more renewable energy and, thus, will contribute to their plans to decarbonise their energy supply, particularly in the Varna region, where there are several energy and carbon-intensive large-scale businesses.

- **Introduce comprehensive financial incentives**: Local SMEs with potential to enter the offshore wind value chain, for example high-tech manufacturers, logistics firms, and port operators, should be supported through limited grant schemes to cover part of the upfront capital investment costs, as well as tax cuts or credits.

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[20] CSD, "Towards a New Regulatory Framework for Offshore Wind Energy Development in Bulgaria", Policy Brief, August 2022

[21] Arsani, A., Koeppen, M., Mikulcic, H., Siwinski, P., Vladimirov, M., "At the Frontier: Guidelines for Unlocking the Offshore Wind Energy Potential in Central and Eastern Europe", Sofia: CSD, 2024

The development of offshore wind farms in the Black Sea requires the extensive **upgrade and expansion of the existing port infrastructure** in Varna and Burgas to enable the completion of the entire supply chain, including the construction, maintenance and decommissioning of wind parks. The port upgrade process should begin in conjunction with the passing of the regulatory framework:

- **Upgrade port capabilities**: Port authorities should plan for future offshore wind projects by expanding and reinforcing the ports of Varna and Burgas, enhancing manufacturing facilities, and improving the interconnectivity capacity of power transmission grids. Ports must be able to efficiently store, unload, and assemble offshore wind equipment, meeting specific criteria such as high load capacity, deep-sea design, and adequate storage space. These activities should be funded through Public-Private Partnerships (PPPs).

- **Invest in specialised vessels**: The Bulgarian shipbuilding industry will also play a key role in the sector's development, which means that it is key to promoting business innovation and collaboration in the offshore wind sector, particularly for construction and maintenance vessels by granting the most relevant firms subsidies and favourable financing mechanisms, geared towards the expansion of maritime infrastructure.

- **Foster local manufacturing**: Bulgaria should develop the local manufacturing capacity for wind turbine components to reduce imports and create jobs, leveraging financial support instruments from the European Green Deal.

- **Establish clear guidelines**: The Offshore Renewable Energy Law should establish transparent procedures for the termination of concessions and the removal of offshore wind infrastructure at the end of a project's lifecycle to alleviate environmental concerns and build trust.

Developing the offshore wind sector in Bulgaria holds opportunities not only for achieving the country's decarbonisation goals and gaining energy independence but for **upscaling the local innovation infrastructure, as well as building cutting-edge industrial hubs**:

- **Provide targeted funding**: The government should ensure access to venture capital and grants to reduce investment risks and accelerate the commercialisation of new technologies. PPPs should be implemented to combine private investment with public oversight to align projects with national energy goals.

- **Foster the local innovation ecosystem:** Local business incubators and accelerators should focus on renewable energy and offshore wind technologies, providing mentorship, funding, and networking opportunities. Varna and Burgas authorities together with the Marine Cluster in Bulgaria should support the creation of innovation hubs to facilitate collaboration among start-ups, ports, the shipbuilding industry, and academic institutions. Partnerships and innovation should be fostered through regular discussions among stakeholders to share insights on regulations, market trends, and innovations.

- **Strengthen regional and cross-border cooperation**: Bulgaria should work closely with Romanian authorities to maximise the offshore wind potential in the maritime border zones. In the early stages, this should include joint exploration and feasibility studies. As the sector matures, joint activities could include grid development projects and shared infrastructure such as ports, maintenance facilities, and supply chains, as well as hubs for the assembly, storage, and maintenance of wind turbines and related equipment.[22]

- **Develop training courses:** The development of the offshore wind sector has the important added value of contributing to the creation of highly skilled jobs. Yet, to meet the needs of the new industry, the Ministry of Education and Science would have to collaborate with the leading technical academic institutions to introduce the necessary, specialised training courses.

- **Map future workforce needs**: Bulgaria must assess and incorporate workforce requirements into national reskilling and upskilling programmes to prepare technical staff for offshore wind projects and ensure that new projects are appropriately staffed for the installation, maintenance and decommissioning stages.

- **Leverage local educational institutions**: The government should support the Bulgarian Maritime University in Varna to train specialists for the construction and maintenance of offshore wind farms and collaborate with vocational schools and other technical universities to create curricula covering engineering, marine logistics, and turbine maintenance. Industry players should establish apprenticeship programmes that bridge academic learning and practical experience in offshore wind projects and offer students direct exposure to real-world operations, allowing them to manage complex equipment and understand operational challenges. The WINDBG Training Centre should provide targeted training sessions, workshops, and certifications to keep the workforce skilled and up-to-date with industry advancements.

[22] Arsani, A., Koeppen, M., Mikulcic, H., Siwinski, P., Vladimirov, M., "At the Frontier: Guidelines for Unlocking the Offshore Wind Energy Potential in Central and Eastern Europe", Sofia: CSD, 2024

The public debate around the development of offshore wind in Bulgaria has been met with a variety of concerns from local communities, as well as society at large. The successful long-term development of the sector requires **high levels of public acceptance** based on the improved understanding of the strategic, economic and societal benefits of offshore wind, as well as any potentially harmful environmental impacts and related mitigation strategies. Awareness raising and consensus building should be an ongoing coordinated effort of all responsible institutions at the national and local level.

- **Collaborate with all stakeholders**: Bulgarian national and local authorities should communicate the broader socio-economic benefits of the offshore wind industry as a way of countering widespread disinformation narratives that have dominated the public discourse and led to a social backlash. To improve social acceptance, government authorities should work closely with local communities, related businesses, and civil society organisations to ensure that offshore wind projects provide broad benefits to society, by holding regular consultations to address concerns and showcase successful projects from other regions. It is key to engage stakeholders early to address local concerns and foster understanding and support for offshore wind initiatives.

- **Highlight benefits for the local community**: Local authorities should communicate the job creation potential of offshore wind projects, which could generate up to 27,000 jobs for the construction of 3 GW worth of offshore wind energy-based generation capacity, stimulating the growth of local economies. Authorities should showcase examples from other countries of how offshore wind projects can enhance coastal tourism and contribute to more biodiversity, potentially attracting tourists and benefiting local ecosystems.

DECENTRALISED ELECTRICITY GENERATION

Decentralised energy systems are a relatively novel concept globally, yet with considerable **technological democratisation and modernisation** potential. The energy sector has historically comprised large, centralised power plants, linked to an extensive transmission and distribution grid sending power to consumers. The objective of decentralised energy systems is to bring energy sources closer to the end user, thus reducing grid inefficiencies and their associated economic and environmental costs. A fundamental aspect of decentralisation is the use of renewables.[23]

Recognising the importance of decentralised electricity generation and consumption, the EU has been providing increasing **support for energy communities** as an effective tool to re-structure national energy systems, while empowering citizens to drive the energy transition process and benefit from higher energy efficiency, lower electricity bills, reduced energy poverty and more local green job opportunities. The 2019 **Clean Energy for all Europeans package** introduced the concept of energy communities. The **Directive on common rules for the internal electricity market** introduced new rules to enable active consumer participation, while the **Renewable Energy Directive (RED III)** and the **Energy Efficiency Directive** enabled Member States to promote energy communities in wind energy and district heating and cooling projects respectively. Furthermore, REPowerEU set out the objective of achieving **1 energy community per municipality with a population of more than 10,000 by 2025**.[24]

Although Bulgaria's **Izgrei energy community**[25] was one of the first four pilot projects of the European Commission's Citizen-led renovation programme, only three of the 123 Bulgarian municipalities with a population of over 10,000 currently host energy communities. The **Burgas** municipality has established an energy community which will power and heat a local public swimming pool and is open to all individuals and companies willing to invest between EUR 250 – 5,000, on which a minimum annual 3% dividend will be paid for 10 years.[26] The **Gabrovo** municipality has established a 100 KW PV facility at a local landfill for non-hazardous waste, with a maximum investment limit of EUR 2,500 per member.[27]

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[23] Chamber of Industry and Commerce for Munich and Upper Bavaria, "Decentralised energy supply versus grid expansion", 2019

[24] European Commission, Energy Communities

[25] European Commission's Citizen-led renovation programme, Izgrei pilot project, 2022

[26] Burgas Energy Community

[27] Gabrovo Energy Community

The first important step towards the **establishment of energy communities in Bulgaria was the adoption of amendments to the Renewable Energy Law in 2023**, aligning the national legislation with Directives 2018/2001 and 2023/2413 on the promotion of energy from renewable sources. The main objective of the amendments was to enable Bulgarian citizens, municipalities and businesses to become drivers of the energy transition, reduce their energy consumption and benefit from the advantages of decentralised production and storage of renewable energy. While this was a step in the right direction, Bulgarian authorities must still provide detailed guidance for the practical establishment and operation of energy communities.

Barriers to Deployment

There is a range of challenges preventing the growth of energy communities in the country. The first major obstacle is the **incomplete regulatory framework**. Transposing the relevant EU legislation is not sufficient, as the latter also contains gaps in definitions and operating procedures left for Member States to resolve in their national provisions. Therefore, simply transposing the Directives, without adequate stakeholder engagement to identify specific national policy gaps, has also led to several inadequacies.

The national legislation **does not provide a clear definition of "renewable energy communities" (RECs) and "civil energy communities" (CECs)**, including with regards to the rights and duties of members, as well as the types of entities, which are eligible to participate. By **restricting the geographic scope** of energy communities to urban areas, they are limited in the types of technologies they can invest in, especially when considering potential investments in wind turbines. Banning entities whose participation in a CEC or REC relates to their main commercial activity should prevent corporate capture by energy companies, but **could also stop RECs and CECs from collaborating**, as by definition their only activity is related to electricity generation, thus barring them from joining a larger community of cooperatives.[28] Furthermore, there are **no legal provisions preventing DSOs from refusing to purchase rooftop PV plants and the energy communities' excess electricity**. Currently, even the smallest energy community is obliged to set up a business venture (without the option, for example for a cooperative or NGO) and operate as a renewable power plant to sell its surplus to a trader, which is an unwarranted administrative and financial burden, further limiting interest in setting up communities.

The delay in the electricity market liberalisation also represents a huge disincentive to the formation of energy communities. The negative effects of regulated prices have already been felt, for example in the Gabrovo project, where customers have expressed interest in purchasing the PV plant's surplus generation.[29] However, because Bulgaria's household electricity market is still regulated and the prices set by the Energy and Water Regulatory Commission are the second lowest in Europe[30], customers have no incentive to make the initial investment to join an energy community and, at least until liberalisation is complete, risk paying higher power prices.

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[28] REScoop EU, Bulgaria

[29] REScoop EU, Bulgarian municipality embracing community energy, September, 2024

[30] Eurostat, Electricity price statistics

The deployment of net metering is also lagging. Due to the lack of a clear political vision for grid modernisation, authorities have not developed any direct requirements or incentives that will push DSOs to roll out smart meters. On their side, DSOs lack the financial resources for full digitalisation, as they would have to transfer the cost to customers thus raising prices. Bulgaria has been awarded EUR 30 million project from the Modernisation Fund to deploy smart meters by the three distribution system operators, but the rollout of over 450,000 devices has been stalled due to administrative delays and is still insufficient to cover all private and corporate customers.[31]

The **obstructions to grid connection** are among the main challenges faced by energy communities in Bulgaria[32]. Not only is public access to data on available grid capacity lacking, but the process of allocating the available capacity is unclear and burdened by heavy bureaucratic procedures. Additionally, estimating and allocating the costs associated with infrastructure expansion and renewal has not been well defined. Hence, investors are burdened with excessive infrastructure upgrade costs and the imposition of multiple grid charges on decentralised energy producers. Another significant hurdle is the **discriminatory practices faced by RES participants within the electricity market**. The absence of clearly defined rules regarding the storage and sale of surplus electricity can lead to inequitable treatment of renewable investors. There is a lack of a clear methodology for regulating feed-in tariffs.

The **lack of a central coordination unit to harmonize practices** among local authorities leads to inconsistent and often slow administrative processes, hindering project implementation. Local authorities and civic initiatives involved in permitting processes typically demand excessive paperwork and have not yet been fully digitised. Relevant authorities frequently fail to meet their own deadlines, often due to limited administrative and professional capabilities to handle applications. Ambiguous or incomplete legal frameworks often lead to inconsistent interpretations by officials, resulting in potentially discriminatory decisions against investors.

There is currently inequitable access to **financial resources** for municipalities and community projects wishing to invest in decentralised energy projects. Furthermore, as many energy communities rely on an initial investment from their members, low-income and **energy-poor households may not have the means to join**. Financial institutions frequently require a robust business case to provide loans, while government subsidies often entail extensive administrative processes and complex application procedures. This emphasises the need for more robust enabling frameworks with suitable instruments for accessing finance and more flexible membership criteria.

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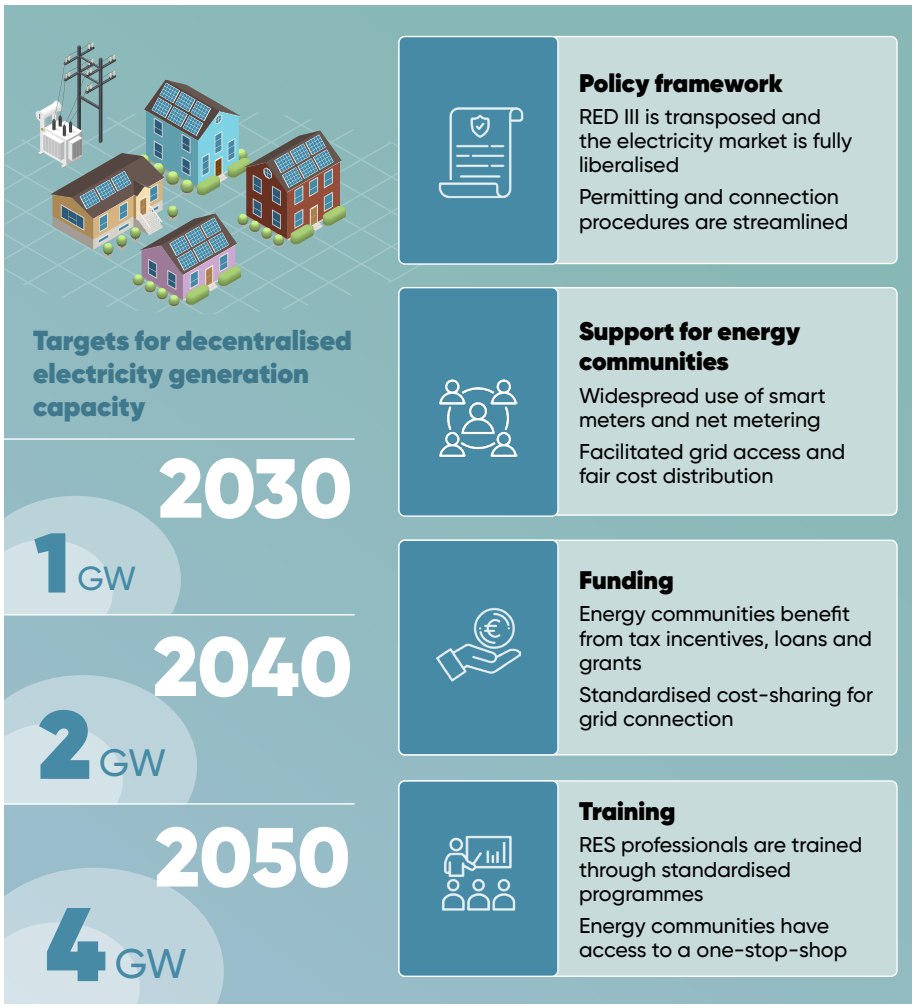
[31] European Commission, "ANNEX to the Commission Decision on the disbursement of revenues from the Modernisation Fund under Directive 2003/87/EC of the European Parliament and the Council - First biannual disbursement cycle of 2023", 2023

[32] Aleksieva, R., Benov, V., Filipova, A., "Green Fast Tracking: Removing Barriers to Decentralization and Democratization of the Energy Transition in Bulgaria", Sofia: CSD, 2024

Strategic Actions

Consistency in energy policies is crucial to ensure the growth of decentralised energy supply in Bulgaria. By **simplifying administrative procedures and streamlining regulatory frameworks**, Bulgaria can reduce investment risks for small-scale RES-based plant owners. To make sure that the proposed decentralisation policies are effective and sustainable, the government should adopt a participatory approach that constructively engages all relevant stakeholders.

Figure 4. Accelerating the decentralisation and democratisation of the Bulgarian power supply



Source: CSD.

Introducing policy and regulatory certainty is a key prerequisite for the development of any new sector. Bulgaria must build on the first tentative steps it has already made to promote decentralisation by harmonising its legislation with EU requirements and developing sensible and fair administrative procedures that will inspire, rather than discourage households and businesses from becoming prosumers.

- **Transpose RED III**: Fully implementing the Renewable Energy Directive III (RED III) into national law will promote decentralised energy systems and citizen-led initiatives. National legislation should improve the definition of energy communities and remove the ambiguity related to their establishment, role and functioning.

- **Liberalise the Electricity Market**: Completing the liberalisation process no later than 1 July 2025, would end state subsidies for the financially non-viable and polluting coal power plants and allow decentralised energy projects to thrive. While market-based price volatility may be too risky for small RES plants wishing to sell their surplus, joining an energy community where the electricity generated can be aggregated from the different individual producers and sold by a virtual power plant to the market could stabilise prices and even create the conditions for the establishment of long-term PPAs with one or several energy users. In addition, a bigger power generating capacity, such as an onshore or offshore wind park, owned by an energy community comprising many members could cover the demand of the whole community, thus minimising the need for power transfers to the grid that can be destabilising its operation.

- **Counter discriminatory practices:** The national regulations should be amended to grant small-scale RES plants equal access to the grid, and clearly define connection procedures, including deadlines and responsible institutions. The rules and conditions for the storage of electricity for different purposes should also be defined to optimise the use of electricity and enable the sale of surplus electricity back to the grid, as part of the licensing regime provided for in the Energy Law.

- **Harmonise permitting processes:** Setting up a unit to coordinate and equalise permitting processes across local authorities and improve efficiency through digital tools and a national registry will significantly facilitate the establishment and management of energy communities and ensure that they are all subject to fair and transparent mechanisms.[33]

Energy communities are a key pillar of the decarbonisation process, which requires the introduction of specific provisions to enable their establishment and operation.

- **Introduce net metering:** Implementing smart meters will allow for precise energy allocation, aiding grid operators in managing decentralised production and incentivising small-scale renewable energy investment, allowing prosumers to offset bills with surplus electricity.

- **Introduce virtual power plant regulatory framework:** Creating standardised procedures for virtual net metering, when balancing the electricity flows of more than one RES plant, participating in an energy community, will facilitate power sharing.

[33] Aleksieva, R., Benov, V., Filipova, A., "Green Fast Tracking: Removing Barriers to Decentralization and Democratization of the Energy Transition in Bulgaria", Sofia: CSD, 2024

- **Streamline grid connection procedures**: The regulatory framework for grid connection should clarify how the financial burden for increasing the distribution grid's capacity is shared among stakeholders, avoiding overburdening investors. The access of energy communities to the electricity market should also be set out, to ensure the fair treatment of all market participants.

- **Implement internal electricity sharing**: The national regulations should provide specific guidance on how energy communities create efficient internal networks of electricity sharing.

- **Unlock funding mechanisms:** Given that an estimated 1.8 million Bulgarians are considered energy-poor[34], unlocking different traditional and innovative funding mechanisms is crucial to ensure that the benefits of decentralisation are accessible to everyone and that vulnerable households are not excluded from the energy transition process. These instruments should be developed in cooperation between the relevant public authorities and private financial institutions alongside the implementation of new legal and administrative procedures. Financial instruments like forward contracts can stabilise revenue and attract investment for decentralised energy projects.

- **Secure funding**: Leveraging available EU funds, the government should establish mechanisms that offer low-interest rate loans or grants to make renewable energy projects accessible to energy-poor households and communities. Promoting crowdfunding and peer-to-peer platforms would also allow local investments in renewable projects, fostering community ownership.

- **Provide government incentives and PPPs**: The government should implement subsidies and tax credits to enhance financial feasibility and encourage participation in decentralised energy projects. At the same time, PPPs and government guarantees should be leveraged to attract institutional investors and reduce perceived risks.

The decentralisation of electricity production results from a widespread understanding of its overarching benefits, efficient market mechanisms and high levels of public support. To **improve social acceptance**, relevant experts should guide the general public in improving the understanding of the energy transition process one stop shops at the local authorities should deploy trained specialists that can conduct feasibility studies of local sites and assist community members in designing projects, which fit their specific energy needs and available resources.

[34] Sustainable Energy Development Agency, "Analysis of the state of energy efficiency in the country and annual progress on the implementation of policies and measures to improve energy efficiency in Bulgaria in 2023", 2024

- **Promote energy communities**: Public acceptance of energy communities can be raised by emphasising cost savings and energy independence, for example, by using successful examples from other countries. Enabling digital tools to provide real-time data on energy production and savings, and empowering citizens to understand their energy use will enhance transparency. Extensive information campaigns should be launched to inform the public about available funding opportunities.

- **Provide accessible information initiatives**: A one-stop shop should provide citizens with guidance on decentralised energy benefits and implementation steps, for example by expanding the Share Renewables platform[35]. Ensuring uniformity in information and services across the country through standardised programmes will promote the balanced development of communities nationwide.

- **Promote training and certification**: Academic and vocational institutions should develop standardised training programmes for professionals in the renewable energy sector to ensure service quality and reliability. Organisations like the Solar Academy[36] and local energy agencies should promote recognised training programmes and mentorship opportunities at the local level.

[35] Share Renewables

[36] Solar Academy

ELECTRICITY GRID MODERNISATION

Europe's electricity system is unprepared for the surge in renewable generation capacity and is undergoing a significant transformation to meet future demand, with a focus on **grid modernisation and expansion** and digitalisation. Europe's transmission grids have faced congestion, curtailment of renewables and long connection queues, showcasing the need for much faster and wide-reaching investments to upgrade electricity systems in line with the exponential rise in new renewable generation across the continent.[37] EU's distribution grid is becoming increasingly outdated - by 2030, 40% to 55% of European low-voltage lines will exceed 40 years in service. Given that electricity will make up 60% of all energy demand by 2050, a substantial overhaul of the electricity grid is imperative.[38] This has led to more specific and focused policy measures from the European institutions, in particular, the 2023 **Grid Action Plan[39],** amendments to the **Electricity Market Design[40]**, and the Council Conclusions on **Sustainable Electricity Grids[41]**.

The other key modernisation element is **smart grid deployment through digitalisation**, which the EU is supporting through the 2022 **Digitalisation of Energy Action Plan**.[42] The introduction of automatic monitoring systems, virtual grids and smart meters can help coordinate the needs and capabilities of all generators, grid operators, end users and electricity market stakeholders, enabling the efficient operation of the entire system. Distribution System Operators (DSOs) can utilise more **detailed data from smart meters** to more effectively manage the grid and optimise capacity. **Customers can modify their consumption** based on the status of the grid and price signals, reducing their energy usage during peak demand or in more congested hours through the implementation of demand-side response programmes. This **reduces costs and environmental impacts** while enhancing system reliability, resilience, flexibility, and stability. Most of the technologies involved have already reached a state of maturity, and thus the tracking of investments provides insights into the levels of deployment.[43]

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37 Ember, Putting the mission in transmission: Grids for Europe's energy transition", March 2024

38 Eurelectric, "Why the distribution grid must be a critical enabler of Europe's energy transition", May, 2024

39 European Commission, Grids, the missing link - An EU Action Plan for Grids, November, 2023

40 European Commission, Electricity market reform, May, 2024

41 Council of the European Union, "Advancing Sustainable Electricity Grid Infrastructure", May, 2024

42 European Commission, Smart grids and meters

43 Publications Office of the European Union, Clean Energy Technology Observatory: Smart Grids in the European Union - 2023 Status Report on Technology Development Trends, Value Chains and Markets, 2023

The European Commission has identified grid upgrades as essential for Bulgaria's energy transition, highlighting the need for investments in smart meters, digital substations, and advanced grid management systems. Modernising the grid would reduce energy losses, improve demand-side management, and increase the resilience of the system to disruptions.[44] **It is also crucial to accommodate the country's growing share of renewable energy,** reducing transmission and distribution losses, and ensuring grid reliability. The ageing infrastructure, over 15,000 km of transmission and about 143,000 km of distribution lines, much of which was developed during the Communist era, requires substantial upgrades to handle the variability of renewable sources like wind and solar and to meet EU energy targets and should focus on increasing digitalisation, deploying smart grid technologies, and improving grid flexibility.

Barriers to Deployment

Bulgaria has access to substantial financial resources to upgrade and modernise its transmission and distribution grids. The TSO is implementing a EUR 611 million project funded under the NRRP aimed at digitalising the transmission grid.[45] A further EUR 857 million have been awarded through the Modernisation Fund and REPowerEU to reinforce 718 km of transmission power lines and upgrade 7 switchyards.[46] The country was also awarded EUR 197 million from the Modernisation fund to upgrade its distribution grid and accelerate electrification, storage deployment, and the decentralisation of energy consumption and production.[47]

While these funds, if fully utilised, will significantly strengthen Bulgaria's grid, the public policy framework on grid upgrades must shift to **prioritise upstream investments to accommodate future RES capacity**. As electricity networks are regulated assets, investments are funded by consumers through network tariffs, and higher development costs raise consumer prices. A supportive regulatory framework for upstream investment is therefore essential for investment certainty, including reforming electricity market design and ensuring transmission access for renewable energy projects. **Balancing long-term infrastructure planning with consumer affordability is key**, as delays in grid upgrades for renewables may result in higher socio-economic costs than early investments. Although Bulgaria's TSO and DSOs have been making some investments, their upgrade plans are based on installed capacity forecasts, which differ significantly from the volume of expressions of interest and signed contracts for connecting to the grid, making planning for system upgrades particularly challenging. For example, the TSO's annual plan foresees a further 13.7 GW of new installed solar capacity by 2030[48], while the draft revised NECP's forecast is for a total of 6.35 GW[49].

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[44] European Commission, "2023 Country Report: Bulgaria", 2023

[45] Electricity System Operator, "Digital transformation and development of ESO EAD's information and real-time systems in a low-carbon economy", 2020

[46] Electricity System Operator, "GREENABLER project", 2024

[47] European Commission, "ANNEX to the Commission Decision on the disbursement of revenues from the Modernisation Fund under Directive 2003/87/EC of the European Parliament and the Council - First biannual disbursement cycle of 2023", 2023

[48] Electricity System Operator, Draft Plan for the Development of Bulgaria's Electricity Transmission Grid for 2024-2033

[49] Ministry of Environment and Waters, Draft National Energy and Climate Plan, June 2024

Furthermore, the **lack of transparency on grid connection procedures** and the approval of new RES capacity in areas where the grid is underdeveloped have led to market destabilisation.

The roll-out of 450,000 devices smart meters for customers is expected to begin imminently, with the implementation of a EUR 30 million project from the Modernisation Fund. However, DSOs will have to contend with **risk aversion among customers**. In choosing between different pricing options, customers tend to focus on the potential for increased costs, not surprising given the high levels of energy poverty, rather than savings. Risk aversion is a principal factor contributing to the significantly higher customer enrolment in default pricing options than in opt-in schemes. On the other hand, research suggests that **customers who are subject to time-varying rates demonstrate high levels of satisfaction** and are inclined to recommend these tariffs to their acquaintances.[50]

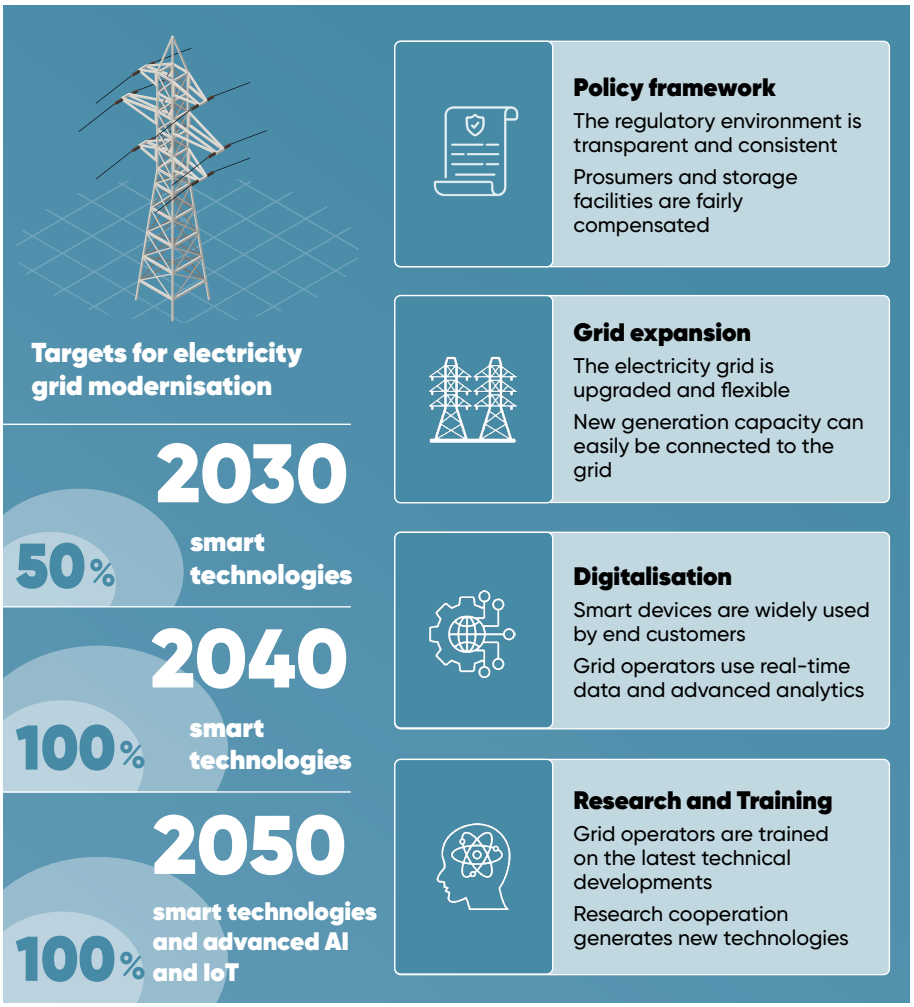
Modernisation and digitalisation must be matched with other key reforms to secure the reliability and flexibility of the grid and accommodate the growing share of RES in the energy mix, which reached over 40% of total electricity generation in the summer of 2024. Bulgaria's largest pumped hydropower storage plant - Chaira, is out of order and is unlikely to resume operations soon, leaving the system without 800 MW of storage capacity. This has stressed the need for **more decentralised and flexible battery storage solutions**, which have also been delayed due to administrative and political roadblocks (discussed in more detail in the next section of the report). The lack of storage makes balancing the system even more difficult and led to balancing prices up ten times higher than normal in May 2024, which the Energy and Water Regulatory Commission (EWRC) had to provide a one-off compensation for. Furthermore, the market is distorted by the regulated and **subsidised household prices**, which are maintained to delay the coal phaseout.

Strategic Actions

Modernising Bulgaria's electricity system will require much more than just the introduction of new physical infrastructure. It must be accompanied by a **complex set of reforms** related to the governance and policy mechanisms of the energy sector as a whole, including market liberalisation coupled with coal phaseout, as well as the introduction of storage technologies. Introducing new technologies will in turn create new value chains if local companies develop new solutions, or upskill their workers to operate with existing cutting-edge technologies.

[50] Zaglago, L., Dzokoto, F., Ankrah, L., "Challenges to Smart Grid Technology", Proceedings of the World Congress on Engineering, 2021

Figure 5. Strengthening the grid resilience for achieving full decarbonisation



Source: CSD.

The first step towards modernising the grid is establishing a **transparent and consistent regulatory environment**, which will enable grid operators to plan for the necessary upgrades and implement the necessary technical changes to accommodate new generation and storage capacity. This process should be led by the Energy and Water Regulatory Commission in cooperation with grid operators.

- **Create regulatory certainty**: Given its crucial role in regulating the electricity system, it is crucial to ensure the independence of EWRC to allow consistent, transparent decision-making free from external influence. This will entail revising Bulgaria's outdated grid management rules to better accommodate decentralised RES and new generation facilities.

- **Provide customer incentives**: Liberalising the electricity market is a key prerequisite to providing system operators with incentives to modernise the grid. Introducing time-of-use tariffs will push consumers to adjust energy consumption based on grid needs and shift demand to high RES generation periods.

- **Ensure fair compensation**: Net metering policies must be fair and balance consumer interests with grid operator needs, ensuring fair compensation for electricity returned to the grid, including from prosumers. New flexible regulations must integrate distributed energy resources, energy storage, and demand response programmes.

Upgrading and expanding the electricity grid is essential to support the energy transition towards renewable sources, as it must handle the variable nature of these sources, ensuring a stable and reliable power supply. Enhanced grid capacity will also enable the integration of distributed energy resources, such as energy storage and electric vehicles. By improving grid flexibility and resilience, upgrades allow for more efficient transmission, reducing congestion and power losses. Grid operators must lead this process, while the government must put in place the right conditions to secure the necessary funding for the upgrades.

- **Use available funding sources**: Bulgaria must continue leveraging national and EU funding sources, including the Modernisation Funds and REPowerEU, to support large-scale grid upgrades, whilst swiftly implementing the projects, which have already been funded.

- **Enable flexible connections**: Grid operators must maximise the use of existing infrastructure to reduce the need for costly and time-consuming expansions. They should also implement flexible connection schemes to optimise grid use based on demand and RES generation, allowing RES to connect when spare capacity exists.

- **Implement technological upgrades**: By leveraging both grant schemes and revenues, the TSO should invest in upgrading transformers, cables, and key grid components, including high voltage direct current lines for efficient long-distance electricity transmission and high temperature low sag conductors to increase capacity without extensive physical expansion. The operator should also explore substation automation for real-time optimisation of electricity flow and supply-demand adjustments.

- **Reuse old assets**: The regulatory frameworks should enable the repurposing and optimisation of underutilised transmission infrastructure and provide guidelines for redeploying obsolete infrastructure for new purposes (e.g. energy storage or microgrids).

The **digitisation of electricity grids** is crucial for enhancing their efficiency, reliability, and flexibility and better managing real-time data to optimise power distribution and balance supply and demand. They can also quickly detect and address issues, reducing outages and improving resilience. Introducing smart devices will empower consumers to monitor and adjust their usage while giving grid operators valuable insights about how to best balance demand, improve efficiency, and quickly address disruptions.

- **Deploy smart devices**: After completing the first phase of smart meter deployment, enabled by the Modernisation Fund, DSOs must continue to install devices that dynamically adjust energy consumption to enhance grid flexibility for all their customers. This will enable real-time energy flow monitoring, improving grid management and outage prevention.

- **Utilise virtual grid**: All system operators should create a digital twin of the national grid for scenario simulations and performance analysis and establish virtual labs to test grid responses in real-time, including during cyber-attacks. Cloud-based data analytics platforms should be used to manage energy data for real-time decision-making and improve grid reliability.

- **Modernise monitoring and analytics**: Following the example of the TSO, DSOs should enhance their SCADA (supervisory control and data acquisition) systems with advanced analytics and Artificial Intelligence to optimise energy flow and stability, reducing the likelihood of equipment failures. They should also deploy advanced distribution management systems to integrate real-time data and improve grid monitoring and control.

Collaboration and research will be key for the faster development and deployment of new technologies, whilst ensuring that grid operators and other relevant stakeholders are well-equipped to operate the upgraded grid.

- **Foster research**: Fostering collaboration among government, grid operators, businesses, and academia will be key to developing innovative solutions for grid modernisation, leveraging public-private partnerships to facilitate technology deployment and share the financial burden of infrastructure investments.

- **Facilitate cooperation**: System operators should join international research projects to accelerate technology development and best practices, prioritising digital power management, distributed generation, and energy storage to advance smart grid capabilities.

- **Provide training**: Grid operators should work closely with academic institutions to address the shortage of specialists in digital and smart grid technologies to ensure successful grid modernisation. Investing in education and training programmes to develop a skilled workforce capable of managing modern energy systems will provide long-term payoff.

ENERGY STORAGE SYSTEMS

Different types of battery systems allow the capture of surplus energy during periods of low demand or high production and store it for subsequent use during peak demand or low production periods. **Energy storage systems (ESS) play a pivotal role in enhancing the stability, reliability, and flexibility of electrical grids** by balancing energy supply and demand. The most widely used technologies include batteries, pumped hydropower storage, compressed air, flywheels, thermal storage, and hydrogen storage. **ESS is enabling the increased use of intermittent, weather-dependent RES**, by capturing and distributing surplus energy based on customer demand.

The location of ESS influences the kinds of services they can provide. When installed **in-front-of-the-meter, power batteries** can provide the TSOs services such as energy arbitrage, spinning reserves, frequency regulation, voltage support and black start, as well as utility services such as resource adequacy, transmission congestion relief, transmission and distribution referral. If they are installed **behind-the-meter**, batteries can ensure the reliability and resilience of the grid, increase PV self-consumption, reduce demand charge and facilitate time-of-use bill management.[51] These services prolong the lifespan of existing infrastructure, either postponing or even eliminating the need for costly investments in power network upgrades. Therefore, **installing battery storage solutions should be considered as an economic alternative when costly upgrades are required**.

In 2023, 17.2 gigawatt-hours (GWh) of new Battery Energy Storage Systems (BESS) were installed in Europe, the third consecutive year when installed capacity doubled on a yearly basis. By the end of 2023, the aggregate operational fleet of BESS in Europe reached approximately 36 GWh. The importance of storage is fully recognised at the EU level, as outlined in the **Commission's Recommendation on Energy Storage**, which encourages Member States to consider storage in long-term grid plans and in the designing of network charges and tariff schemes so that they provide revenue predictability through a clear regulatory framework.[52]

The Bulgarian government recognises the importance of storage, given its longstanding experience with **pumped storage hydro power**. The country's main HPP, Chaira and the largest of its kind in the Balkans has been out of order since March 2022, depriving the electricity system of 800 MW of storage capacity. The plant's mismanagement and long delays in running regular maintenance procedures were compounded by a period of overproduction in 2016-2019. Even if the plant's owner, the National Electricity Company, attracts a subcontractor to repair the facility, the process will not be complete before 2028 at the earliest, putting into question how the grid will be able to

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[51] Couture, T., Frost, J., Jacobs, D., Primova, R. Rangelova, K., 10-Point Plan to Scale-up Energy Storage in South East Europe, Sofia: CSD, 2022

[52] Commission Recommendation on Energy Storage – Underpinning a decarbonised and secure EU energy system, March 2023

balance the foreseen new RES projects. Nevertheless, the Chaira HPP holds even more potential for the future of Bulgaria's decarbonisation, as there are plans to significantly **increase its capacity by connecting its lower reservoir to the planned Yadenitsa Dam** through a reversible pressure tunnel, which would increase the plant's continuous operation time in power generation mode from 8.5 to 22 hours.[53] There are additional **plans to construct two new HPPs at Batak and Dospat dams** using the existing Batak waterway, which would provide approximately 800 MW of new installed capacity in generation mode and 730 MW in pumped storage mode each.[54] If the government can secure the estimated EUR 1.8 billion for their construction, they will not be operational before 2032. By mid-2024, the National Electricity Company had signed an agreement with the European Investment Bank for feasibility studies and requested EUR 150 million through REPowerEU, which is in question due to the delays in implementing the necessary reforms under the NRRP.

Chaira HPP's breakdown has highlighted the urgent **need for Bulgaria to deploy smaller, more flexible storage solutions** in the form of battery storage, which can more efficiently facilitate the ongoing surge in PV investment, expected to last at least until 2030. BESS will support grid flexibility, enabling higher integration of renewable energy sources and reducing peak loads[55] and up to 3.5 GW of installed storage capacity is envisaged in Bulgaria's draft revised NECP[56]. The first important step towards achieving this goal is the launch of the **National Renewable Energy Storage Infrastructure Programme - RESTORE**, envisaged by the NRRP[57]. The EUR 590 million programme supports the purchase, installation and commissioning of electricity storage facilities with a minimum charging capacity of 3000 MWh, which should be operational by March 2026. This programme will help compensate for the absence of Chaira's storage capacity and could potentially cover a big share of the country's balancing needs if the batteries can discharge electricity for 4 hours at peak demand times.

Barriers to Deployment

The progress made to date in developing Bulgaria's BESS sector still faces challenges in the form of regulatory gaps, and the need for policy incentives to attract investment in storage infrastructure. The first major barrier to the decarbonisation of Bulgaria's economy as a whole is the **lack of political will to truly reform the energy sector**, because of the strong vested interests blocking decarbonisation. The delay in liberalising the electricity market, in large part to secure state subsidies for the coal power plants, is effectively blocking the market forces, which will inevitably boost the much-needed development of ESS to complement the PV surge and balance the grid.

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[53] National Electricity Company

[54] Ministry of Environment and Waters, Draft National Energy and Climate Plan, June 2024

[55] Aleksieva, R., Diallo, A., Rangelova, K., Szabo, L., Vladimirov, M., "Decarbonising the Bulgarian Power Sector", Sofia: CSD, 2023

[56] Ministry of Environment and Waters, Draft National Energy and Climate Plan, June, 2024

[57] Ministry of Energy, Launch of National Renewable Energy Storage Infrastructure - RESTORE, August, 2024

Furthermore, the current **policy and market frameworks do not yet recognise the pivotal role of energy storage in facilitating a greater penetration of renewables**. In Bulgaria, as in many other EU countries, energy storage is classified as a generation asset, suitable for large-scale projects but not smaller ones. The lack of long-term contracts creates revenue uncertainty and increases capital costs. Double taxation on charging and discharging is also a widespread regulatory gap. Ancillary service markets, key revenue streams for storage, are underdeveloped and often not based on market forces. The current policy and regulatory incentives favour large transmission investments over storage solutions, and energy storage technologies are not fully integrated into national strategies or roadmaps. Although they are desperately needed to cover peak demand at night, ESS are not yet well integrated into balancing markets. The three Bulgarian DSOs are also hampering the development of ESS by effectively **not allowing smaller-scale hybrid solar projects to sell their surplus back on the market**, making investments in batteries redundant if producers cannot sell electricity when the consumer needs it most.

A major challenge for the long-term integration of both RES and storage technologies is the lack of adequate contractual mechanisms for reducing final electricity prices and increasing low-carbon competitiveness, not only in Bulgaria but across the EU at large. Russia's invasion of Ukraine led to an electricity crisis due to the dependence of the power market on much more expensive natural gas as the clearing source in the merit order.[58] The use of long-term contracts, such as Power Purchase Agreements (PPA) or two-way Contracts for Difference (CfDs) can weaken this link but has so far not been widely deployed.[59] Although several long-term PPAs have already been signed in Bulgaria, including the first virtual PPA for one of the largest new solar plants[60], these mechanisms must be further promoted and utilised.

Strategic Actions

While the first steps towards expanding Bulgaria's storage capacity were taken with the launch of the NRRP tenders, there is a need for a robust regulatory environment that provides financial incentives and stimulates the necessary technical upgrades to the grid.

Legal ambiguities should be minimised to avoid project delays and reduce investor risk by **establishing a comprehensive regulatory framework**, which defines the role of storage in the broader energy system, reducing legal ambiguities and providing predictability and a level playing field to potential investors.

- **Develop a regulatory framework**: Bulgaria must develop a national regulatory framework for energy storage that aligns with EU laws and the Internal Electricity Market Directive, covering all aspects of energy storage, including licensing, market participation, and integration with renewables, to allow full participation in energy trading and arbitrage. Power-based storage must be defined as a separate activity or asset category, tied to a clear policy framework and a binding target.

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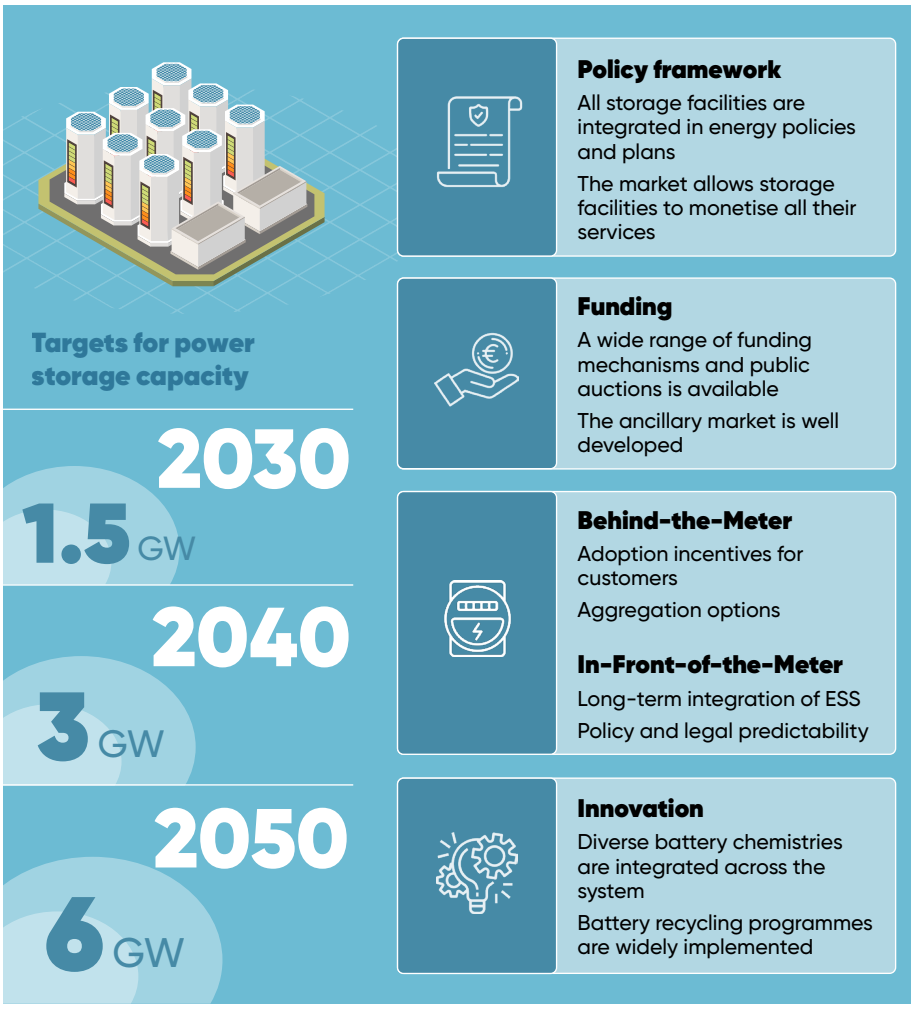
[58] European Parliament, Improving the design of the EU electricity market, July, 2024

[59] Draghi, M., "The Future of European Competitiveness", September, 2024

[60] Capital.bg, "Purchasing electricity, without using it", September, 2024

Figure 6. Upscaling energy storage technologies for a more balanced energy transition



Source: CSD.

- **Enhance market mechanisms:** BESS must be able to monetise the various services they provide, such as energy arbitrage, capacity provision, spinning reserves, and frequency response. The system should move closer to real-time electricity markets with shorter settlement times to create clearer opportunities for rapid response technologies like ESS.

- **Streamline licencing procedures**: Clear and simplified licencing procedures for grid-scale storage options should be adopted and Ordinance 6 should be updated further to remove the cumbersome requirement of a EUR 25,000 capacity deposit for preliminary contracts, for storage. The deposit requirement for renewables was put in place to reduce speculative grid connection applications by investors not interested in completing a RES project, but potentially selling it to a bigger portfolio investor at a premium.

Bulgaria should establish **financial incentives to attract investment** in storage technologies, targeting both large-scale grid-connected systems and behind-the-meter installations.

- **Use innovative financing models**: Different financing models should be developed, involving collaboration between investors, commercial banks, and end customers. Grid operators should have access to targeted incentives to invest in storage and not only in transmission system upgrades.

- **Introduce auction models:** The regulator should introduce competitive bidding processes or auctions for storage or hybrid renewable energy projects, using best practices from the region as examples.

- **Launch ancillary market**: An ancillary market must be developed to maximise profits for hybrid or individual storage facilities for providing ramping, contingency spinning and replacement reserve, voltage support and black-start capacity.

- **Develop long-term contractual frameworks**: Promote the widespread use of Power Purchasing Agreements (PPAs) and Virtual PPAs, where the buyer does not physically receive electricity from the contracted generation capacity but obtains power from a wider portfolio of different renewable assets.

One of the challenges for storage is that few electricity markets remunerate the full range of services that batteries provide. There is currently a disconnect between the value that storage technologies bring to the system (and to power system resilience and decarbonisation efforts) and the revenues they can earn. Better **integration of storage technologies into the power system** planning is crucial to unlock their full potential. Based on their type and location, they can be stimulated through a range of policy measures.

Behind-the-Meter Storage (located on the customer's premises):

- **Introduce adoption incentives**: The government should provide special fiscal and financial incentives to encourage customer-sited storage adoption, mitigating the risks of a public backlash against storage technologies. There should be no double taxation (on charging and discharging) of customer-sited battery assets. Special, time-varying electricity rates should be introduced to encourage smarter energy management.

- **Enable aggregation**: Regulations should facilitate the emergence of aggregators that can group small-scale battery storage systems to provide more value to the power system as a whole.

In-Front-of-the-Meter Storage (directly connected to the grid):

- **Plan for long-term ESS integration**: The TSO and DSOs should include storage in their future planning and modelling, which will reduce investment needs and make full use of the range of services provided by storage solutions.

- **Policy predictability**: The government should avoid sudden, erratic changes to policy, regulatory, and electricity market structures, such as electricity price caps, which can discourage investments in energy storage, which can help sustainably and durably mitigate price spikes in the future.

Promoting a wide range of storage technologies will reduce reliance on specific materials and resources, enhance system resilience, as well as foster the local **innovation** ecosystem and improve energy security.

- **Diversify technologies**: Bulgaria should support diverse battery chemistries and invest in local recycling and second-life applications to build a resilient energy system. Introducing targeted measures for thermal storage, which holds enormous largely untapped potential, could improve household-level and regional energy security and reduce imports of fossil gas.

- **Reduce environmental impact**: Improving circularity in the business model through investments in recycling and second-life uses can reduce environmental impact and create economic opportunities.

WHAT'S NEXT?

Bulgaria can activate nearly EUR 5 billion in EU funds from the Recovery and Resilience Facility, the Modernisation Fund, REPowerEU, the Just Transition Mechanism and the EU Structural Funds to boost investment in low-carbon technologies. These funds should be invested in **four key technologies, which will both diversify Bulgaria's energy mix and facilitate the more secure and efficient distribution and storage of the generated electricity**:

- **unlocking Bulgaria's offshore wind energy potential in the Black Sea;**
- **enabling decentralised electricity generation and the establishment of energy communities;**
- **expanding and modernising the power transmission and distribution grids and introducing smart metering;**
- **integrating large-scale electricity storage systems.**

This requires a complex set of coordinated policy actions, coupled with financial incentives and new market mechanisms, but if implemented in a timely, transparent and evidence-based manner, will catalyse not only Bulgaria's decarbonisation, but also the country's economic development and competitiveness. Alongside the sector-specific measures for each of the four technological areas, this analysis suggests they would all benefit from several **common reforms, which would facilitate the deployment of low-carbon technologies**, strengthen the electricity market and help Bulgaria achieve its decarbonisation vision:

- The Bulgarian government must urgently **complete the regulatory framework** surrounding renewable and storage technologies and grid modernisation to provide policy clarity and predictability. Authorities should transpose all relevant EU legislation and resolve all remaining regulatory gaps and ambiguities to provide investors with a fair, predictable and transparent policy and market environment.
- Any new legislation and policy measures should be developed based on **scientific evidence and the latest technological advancements**, detailed and up-to-date data, proven best practices and wide stakeholder engagement, to build public trust in the decision-making process and promote good governance principles in the energy sector.
- **Electricity market liberalisation and coal phaseout** must be completed to unlock the potential of renewables, thus reducing price volatility, improving market liquidity, stimulating the development of energy communities and providing bigger incentives for grid operators to modernise the electricity grid.

- All new or updated **national strategic and planning documents** (e.g. the NECP, the future Sustainable Energy Development Strategy, the Marine Spatial Plan, the TSO and DSO's long-term development plans) should fully account for the rapid expansion of renewables and storage facilities, planning accordingly to accommodate this growth. Part of the planning process should include the **mapping of priority zones for renewables** deployment, including in the Black Sea.

- Authorities should urgently **unbundle the Bulgarian Energy Holding** by separating the power and natural gas TSOs from the Holding structure, a key reform under the NRRP.

- The regulator should **simplify the cumbersome grid connection procedures** for all new market entrants by providing transparent information about the capacity at all grid connection points, a public methodology for assessing and lowering connection costs.

- All available market tools should be fully utilised to enable renewable and storage facilities to **sell surplus electricity to the market** in simple and fair procedures, recognising the key role these technologies play in balancing the market.

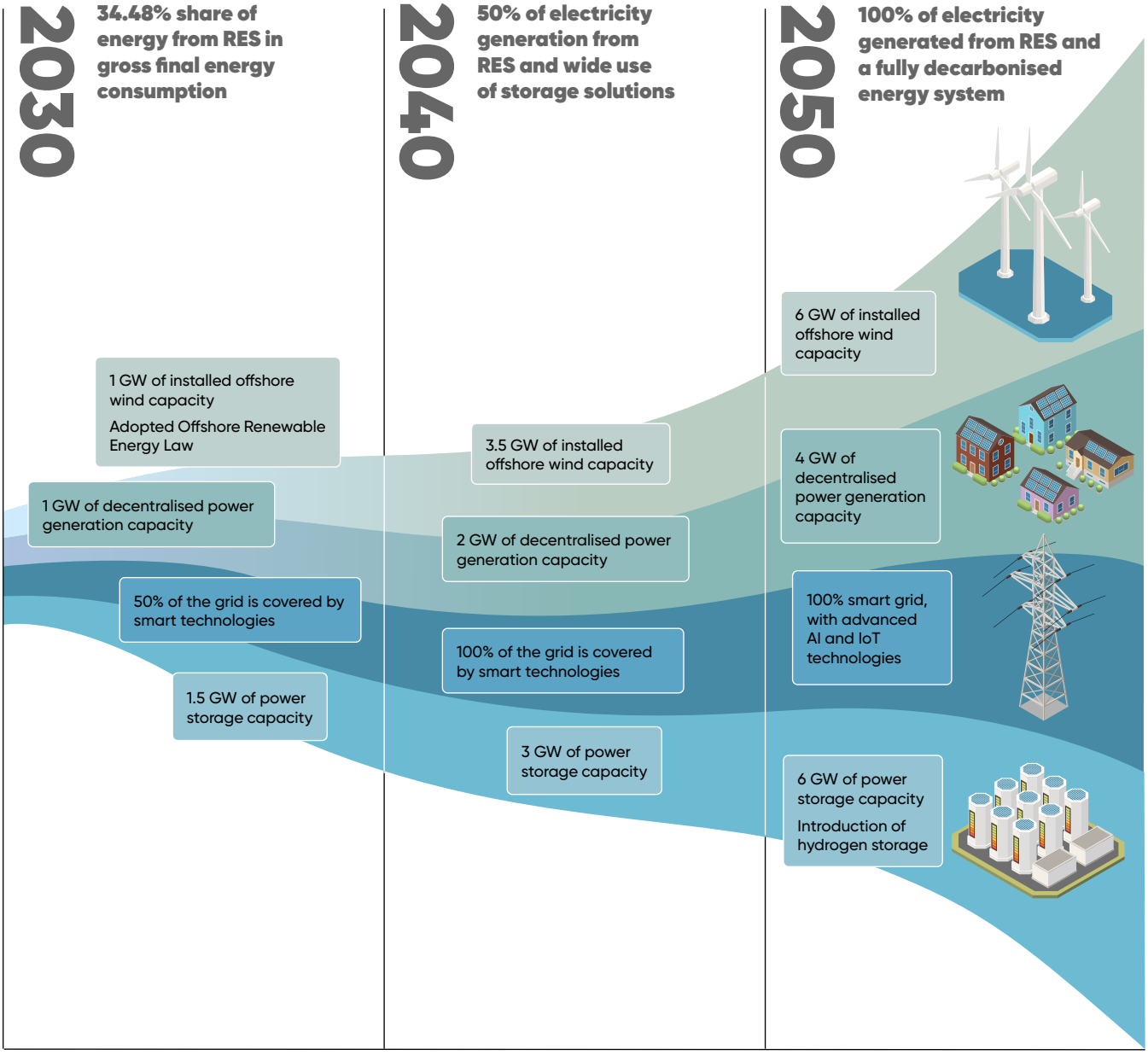
- The government should **leverage all available funding sources**, including EU instruments such as the NRRP, the REPowerEU Initiative and the Modernisation Fund, to secure investments in large-scale projects (e.g. transmission grid modernisation and HPP construction), and provide guarantees to unlock private funding and loans for smaller-scale facilities.

- The market should promote and use all available **long-term purchasing mechanisms** (e.g. PPAs, VPPs and CfDs) to provide revenue predictability to investors and stimulate further low-carbon growth.

- Public authorities should **assess the technical and administrative skills gap** for low-carbon technologies' development, installation, maintenance and decommissioning and work with academic and vocational institutions to **develop targeted training** programmes, thus creating jobs.

- Holding regular stakeholder consultations and implementing awareness-raising campaigns, explaining the economic, social and environmental benefits of low-carbon technologies and the key role that citizens play in the energy transition process, will build stronger **public support for decarbonisation**.

Figure 7. Long-term vision for Bulgaria's decarbonisation in four key areas by 2050



Source: CSD