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Governance policy of digitalization in the energy sector

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List of abbreviations

AI	Artificial Intelligence
AMP	Africa Minigrids Program
EVRF	Energy Vulnerability Reduction Fund
FEC	Fuel and energy complex
ICC	Industrial competence centre
IoT	Internet of Things
IT	Information technology
ML	Machine Learning
PV	Photovoltaics
QAMF	Quality Assurance and Monitoring Framework
RES	Renewable energy sources
SIS FEC	State information system of the fuel and energy complex
SV DT FEC	Strategic vector of digital transformation in the fuel and energy complex until 2030
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme

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Introduction

The challenge of climate change is prompting diverse approaches to the global energy transition across different regions:

- Europe largely focuses on integrating renewable energy sources (RES) and achieving net-zero emissions;
- North America emphasizes energy independence and innovation in clean technologies;
- Sub-Saharan Africa and many developing regions prioritize sustainable expansion of access to electricity;
- In Asia, the primary goal is to meet the rapidly increasing energy demand sustainably, balancing economic growth with environmental considerations.

Digitalization has the potential to revolutionize energy systems by optimizing energy production, distribution, and consumption through advanced technologies like smart grids, Internet of Things (IoT), blockchain, and Artificial Intelligence (AI) / Machine Learning (ML). These technologies offer real-time data management and analytics, improving energy efficiency and reliability while supporting a more seamless integration of RES, including by enabling new business models in demand response and peer-to-peer local and flexibility trading. From a governance perspective, digitalization can improve transparency and accountability, ensure equitable access to energy including citizen participation in energy markets, engaging a broader range of stakeholders in decision-making processes and addressing the needs and aspirations of all segments of society, including the most vulnerable.

Viewing the digital transformation of the energy system through a governance lens is essential to navigate the emerging opportunities and challenges of an increasingly distributed energy market. By adopting a proactive approach, governance can harness digital technologies to improve monitoring, forecasting, and decision-making processes, ensuring that the energy transition is both efficient and inclusive. This approach also provides the flexibility to adapt to emerging challenges, such as data privacy concerns, the digital divide, low standardization and compatibility across different technologies and regions, the difficulty of balancing rapid innovation with the need for effective regulation, the need for digital and energy literacy and new skills and expertise, environmental concerns related to digital technologies, and the necessity for strong cybersecurity measures. Effective governance must navigate these complexities to harness the full potential of digital technologies while safeguarding the interests of all stakeholders.

Therefore, the digital transformation of energy systems presents a unique intersection of technological advancement and governance innovation. By leveraging digital tools within a robust energy governance framework, stakeholders can achieve a more resilient, secure, sustainable, and inclusive energy future.

Governance dynamics in the digital transformation of the energy system

In the complex global context, the United Nations Development Programme (UNDP) has developed an energy governance framework that underscores the importance of effective, inclusive, and accountable governance of the energy transition globally.[1] This framework recognizes that digitalization facilitates transparency, enhances stakeholder participation, and ensures that energy policies are more coherent, effective, and responsive to the needs of all people and communities. Therefore, the integration of digital technologies as tools to improve governance outcomes is a key component of the framework. Current trends in energy digitalization

Energy digitalization is transforming the energy landscape, driven by several key trends and technologies:[2]

- **Smart grids** are being implemented, enhancing grid reliability and efficiency by using digital technology to monitor and manage electricity flows in real time;
- **IoT** devices, such as smart meters and sensors, enable real-time data collection and analytics, improving energy management and operational efficiency, especially when providing granular, asset-level measurements;
- **AI** and **ML** are used to predict energy demand, optimize supply, and enhance fault detection, enabling better data-driven decision-making and cost reductions.
- **Blockchain** technology is facilitating a more secure, transparent albeit privacy-embedded and efficient energy data management and information exchange among different energy market participants, while also enabling automated, efficient peer-to-peer energy exchange.
- **Energy storage** systems, such as advanced batteries and thermal storage, are being integrated with digital platforms using cloud computing and big data analytics, as well as increasingly AI and blockchain, to optimize energy storage and distribution, balance supply and demand, and enhance grid stability.

These technological advancements are not only reshaping the energy sector but also influencing the dynamics among stakeholders:

- **Stakeholder dynamics** are evolving, with traditional stakeholders like utility companies and government agencies rapidly adapting by investing in digital technologies and upskilling their workforce. New entrants, including technology companies and startups specializing in Big Data, AI, IoT, blockchain, renewable energy firms, energy storage innovators, other software developers, and financial institutions focusing on green investments, are bringing innovative solutions to the market. This shift is redefining roles,

[1] See: https://www.undp.org/publications/strengthening-energy-governance-systems-energy-governance-framework-just-energy-transition

[2] See: https://unece.org/sites/default/files/2020-12/GEEE-7.2020.INF_.3.pdf

responsibilities, and interactions within the energy sector, driving a more collaborative and integrated approach to governance.

- **A more customer- and citizen-centric energy landscape** is emerging as digitalization empowers consumers and prosumers to have greater control over their energy use and a more active energy market participation through digital platforms and smart devices. Citizens can now make more informed choices, promoting energy efficiency and sustainability and increasingly engaging in demand response and local energy trading.
- Importantly, digitalization empowers **prosumers** – households or communities that both produce and consume energy – by owning or leasing distributed energy generation, such as solar panels and wind turbines, which is managed and optimized via smart technologies. This shift not only promotes decentralized energy trading and enhances market transparency but also contributes to more resilient and democratized energy systems, allowing citizens to actively participate in the energy market and influence how energy is produced and distributed.

Regulatory frameworks are evolving to support the digital transformation of the energy market:

- **Policy evolution** is increasingly oriented toward a user-centric approach, driven by digital technologies that enable better monitoring, peer-to-peer energy trading, and dynamic pricing models. Regulators are facing the new challenge of developing frameworks that encourage innovation while ensuring grid stability and consumer protection, data privacy, and cybersecurity.
- **Regulatory adaptation** includes creating incentives for digital investments, addressing challenges like cybersecurity risks, and ensuring the integration of digital technologies aligns with grid reliability and resilience. However, these measures are still not fully implemented, presenting a significant challenge for regulators to ensure a smoother transition towards a digitalized, decentralized, and decarbonized energy system. Establishing clear standards and fostering a more supportive environment will be essential to achieving this goal and bridging the gap between the opportunities provided by new technologies and the current legislative framework.

The changing energy landscape underscores the importance of a robust governance framework to manage these transformations effectively. Digitalization brings both opportunities and challenges, and by adopting a governance lens, stakeholders can navigate the complexities, ensuring that digital advancements contribute to a resilient, sustainable, and equitable energy future. By implementing robust governance frameworks, stakeholders can ensure that digital technologies are deployed responsibly, protecting sensitive data, maintaining security, and fostering inclusivity. This approach not only harnesses the full potential of digitalization but also drives progress while safeguarding public trust and promoting broader societal benefits.

Digitalizing energy governance: key considerations

In the evolving landscape of energy, digitalization serves a dual purpose: it enhances energy governance mechanisms while also requiring stringent governance over the digital components themselves. Digital tools can significantly improve the efficiency, effectiveness, transparency, and responsiveness of energy systems, as seen with smart grids that leverage real-time data to optimize energy distribution, balance loads, and reduce wastage. However, implementing these tools across various regions presents challenges, particularly in areas with limited infrastructure or regulatory support.

As digital technologies become more embedded in energy systems, the need for strong governance frameworks becomes increasingly critical. These frameworks must address crucial issues such as cybersecurity, data privacy, and the ethical use of technology. The collection of sensitive data on consumer behaviour and energy usage by digital tools underscores the importance of maintaining consumer trust and adhering to regulatory standards. Yet, rapid digitalization can outpace governance, potentially leading to gaps in oversight and unintended consequences that could undermine the related benefits.

Furthermore, the governance of digital components is vital to ensuring that these technologies are deployed effectively and responsibly within energy projects. Establishing clear cybersecurity policies and standards is paramount, especially as energy grids become more interconnected, thus vulnerable to cyber threats. Effective governance also involves ensuring data integrity and transparency, enabling stakeholders to rely on the information provided by digital systems. However, governance must be careful not to stifle innovation, as overly stringent regulations could hinder the adoption of new technologies that could otherwise enhance energy systems.

As emerging technologies such as AI and IoT are being integrated into energy systems, governance must ensure that these innovations are effectively aligned with traditional energy infrastructures, enhancing their overall performance and compatibility. A smooth transition to new technologies requires a governance approach that balances risk mitigation with the encouragement of innovation. By fostering an environment where digital advancements integrate seamlessly with existing systems, this forward-thinking strategy will contribute to a more efficient, resilient, and sustainable energy landscape. Effective governance of digital technologies in energy policies and projects requires a balanced strategy that promotes technological progress while protecting against potential risks. This ensures that energy systems remain secure, transparent, and aligned with the highest ethical and regulatory standards.

Following are the key four key components to work upon while ensuring the effective governance of a digitalized energy system:

1. **Inclusive and effective institutions.** Digitalization plays a pivotal role in transforming energy governance institutions to be more inclusive, effective, and aligned with the goals of a just energy transition. Advanced data analytics optimize decision-making by providing deep insights into energy consumption patterns, forecasting future needs, and ensuring that resources are allocated efficiently and equitably. Digital tools also help institutions bridge the gap between urban and rural, especially remote areas, enabling the extension of energy services to underserved populations and promoting universal access to sustainable energy.

By leveraging digital platforms, energy institutions can foster greater public participation, allowing diverse stakeholders to contribute to policy-making processes and ensuring that the transition is not only technologically advanced but also socially equitable. Furthermore, digitalization facilitates continuous learning and adaptation within institutions, enabling them to respond quickly to emerging challenges and integrate innovative solutions. By creating a more transparent, participatory, and adaptive governance framework, digital tools empower institutions to lead a just energy transition that is responsive to the needs of all communities and resilient to future disruptions.

2. **Policy and regulatory frameworks**. Digital tools are revolutionizing policy-making and regulatory frameworks in the energy sector by enabling more agile, data-driven, and coherent approaches that can swiftly adapt to a fast-evolving landscape. Advanced blockchain-enabled data management combined with AI-enabled data processing capabilities provide national regulatory authorities with increased granularity and accuracy of data from operators, allowing them to monitor individual network components and manage their interaction more effectively. This enhanced visibility reduces information asymmetry between regulators and operators, as well as service providers that are dependent on granular data access, offering a comprehensive overview of network performance and enabling a more competitive and advanced market services. Notably, regulators can innovate their frameworks by developing new incentive schemes that promote proactive network management and drive efficient operations. Additionally, digital platforms enable real-time updates to regulatory frameworks, ensuring they remain relevant as new technologies and trends emerge and grow, such as renewable integration and decentralized systems. At times they also require a novel market design, transitioning from centralized to bottom-up asset-level energy management. These platforms also democratize the regulatory process by broadening stakeholder engagement, ensuring that policies are socially equitable and inclusive. By enhancing transparency and accountability, digitalization strengthens trust in the governance process, making energy policies more responsive and forward-looking.
3. **Civic engagement and empowerment.** Digitalization significantly enhances civic engagement in energy governance by enabling broader public participation through tools like social media, online platforms, and virtual forums. These platforms democratize access to information, empowering citizens with the knowledge to make informed decisions and advocate for sustainable energy practices. Moreover, they facilitate real-time feedback, allowing governments and energy companies to tailor policies and services to community needs, fostering a more responsive governance system. Digital tools also enable the creation of local energy cooperatives or communities that take control of their energy use and actively participate in the energy markets, driving grassroots innovations and increasing individual contribution to the energy transition. Additionally, by enhancing transparency and accountability through interoperable and informative data platforms, digitalization ensures that energy governance remains aligned with public interests, paving the way for more equitable and sustainable energy systems. This shift not only empowers communities but also bridges the gap between policy and practice, making energy governance more inclusive and adaptive to future challenges.

4. **Appropriate and independent oversight.** Integrating digital tools into the oversight mechanisms of the energy sector significantly enhances their effectiveness and independence. Real-time monitoring and advanced reporting systems enable continuous oversight of energy production, distribution, and consumption, allowing for the early detection and resolution of issues. Decentralized blockchain-based energy asset data management results in higher system interoperability and more effective value chain management, with higher transparency and security of data, whilst ensuring privacy. AI and ML further can elevate the auditing process by identifying anomalies and inefficiencies with precision, enabling predictive analytics to anticipate risks. Digital public transparency mechanisms, such as online dashboards and open data initiatives, provide oversight bodies and civic organizations with accessible, actionable information, fostering higher standards of accountability and public trust. Furthermore, institutions such as anti-corruption agencies, human rights organizations, and consumer protection agencies can leverage digital tools to play a more effective oversight role in the energy transition. These institutions can use digital platforms to track and report unethical practices, ensure that energy policies respect human rights, and protect consumer interests by monitoring pricing and service quality. By facilitating independent data verification and creating platforms for open scrutiny, digital tools ensure that oversight institutions, including these critical agencies, remain impartial and robust, upholding the principles of transparency, fairness, and integrity in energy governance.

Examples of projects integrating digital innovations into energy governance

This section presents examples that highlight the digital transformation of energy systems across different regions and national contexts. These projects provide valuable insights into the challenges faced, strategies employed, and outcomes achieved in integrating digital technologies into energy governance. By examining these real-world examples, one can derive lessons that inform future efforts in enhancing the resilience, efficiency, and inclusiveness of energy systems.

Specialized digital tools and solutions for minigrids (Africa)

Background and context

RES-based minigrids, especially solar-battery minigrids, present a significant opportunity to provide electricity to 490 million people globally,[3] with a significant focus on sub-Saharan Africa. This opportunity is driven by declining hardware costs, advances in digital technologies, and innovative private sector business models. However, scaling minigrids faces challenges, particularly in mobilizing private sector investment and navigating the multitude of stakeholders with different interests, who are often lacking coordination. As a result, the minigrid market in Africa remains underdeveloped, with most investments heavily reliant on grants and patient capital. This dependency is largely due to the significant upfront capital expenditures and the low ability and willingness of customers to pay for electricity. Achieving true scalability in this sector

[3] https://openknowledge.worldbank.org/server/api/core/bitstreams/32287154-1ccb-46ce-83af-08facf7a3b49/content

would require securing substantial commercial financing, particularly through commercial debt. However, obtaining such financing would depend on improving the economic viability of the business model.

The ongoing Africa Minigrids Program (AMP) is designed to address these challenges by supporting clean energy access and promoting commercial investment in minigrids across 21 African countries.[4] The programme, aligned with the UNDP Digital Transformation framework, involves a broad coalition of stakeholders, and aims to establish a conducive environment for substantial private investment in minigrids and to enhance financial viability and scale up investment by focusing on cost-reduction strategies and innovative business models, which will benefit end-users through lower tariffs and improved service.

Digital initiatives

AMP has a distinctive chance to encourage the adoption and utilization of digital tools within the sector and can also curate and promote existing specialized digital tools and solutions tailored to the off-grid and minigrid sectors.[5] AMP includes:

- A digital strategy to improve minigrid scalability using specialized tools and solutions, informed by national digital readiness assessments tailored to the minigrid subsector. This activity involves developing a regional digital strategy aimed at improving the scalability of minigrids through the use of specialized digital tools and solutions. National-level project digital strategies specific to each participating country will then be developed in alignment with the regional digital strategy, and following the conduction of national digital readiness assessments tailored to the minigrid subsector. The importance of this output lies in its potential to streamline operations, reduce costs, and facilitate the deployment of minigrids on a larger scale, thereby accelerating access to reliable electricity in underserved areas.
- A framework for data security and consumer protection, along with a standardized Quality Assurance and Monitoring Framework (QAMF) for minigrid pilots Standardization of data and data collection protocols, applied to all AMP minigrid pilots, and disseminated across the minigrid sector. This focuses on developing a framework for data security and consumer protection, which will support data security across the entire minigrid sector. Additionally, this output includes the creation of a standardized QAMF for the minigrid pilots implemented across the programme, ensuring consistent quality and performance monitoring. Here again, a tailored national-level QAMF will be derived from the standardized one in each participating country to take into account national specificities. Ensuring strong data security and consumer protection is crucial for building trust among users and stakeholders, while the QAMF will ensure that minigrid projects maintain high data quality standards, leading to more reliable and sustainable energy solutions.

[4] See: https://www.undp.org/energy/our-flagship-initiatives/africa-minigrids-program

[5] See: https://www.undp.org/digital/transformations

- A regional digital platform to aggregate data from national projects, facilitating seamless integration and coordination. Data from AMP minigrid pilots will be aggregated digitally at national and regional level, creating value for the sector through insights and regional learning. This involves setting up a regional digital platform designed to aggregate data collected by national digital platforms, thus facilitating seamless data sharing and coordination. The importance of this platform lies in its ability to provide – through the alignment of all national projects with the programme-level QAMF – a unified view of data across multiple projects, enhancing collaboration, improving decision-making, and enabling more effective management and monitoring of minigrid systems.
- The development of a standardized, aggregated dataset to enhance energy access planning and support informed decision-making across the sector. Demonstration of automated data analysis for minigrid development, builds on the standardized, aggregated dataset developed in the previous activity, presenting an important opportunity to enhance informed decision-making and strategic planning for expanding energy access through minigrids. The importance of this standardized dataset is that it enables policymakers, planners, and developers to base their strategies on accurate, up-to-date information, leading to more effective and targeted interventions to improve energy access in remote and underserved regions.
- Digital advocacy and communication tools to enable and facilitate national policy dialogues for AMP national projects. Through its regional-level community of practice and the various inclusive multi-stakeholder platforms and fora established at national level, AMP aims to sensitize key actors of the minigrid sector on the opportunities offered by digitalization. This is further achieved by developing and disseminating suitable knowledge tools as different use cases are implemented, to demonstrate benefits and lessons learnt.

Lessons learned to date

The following preliminary observations can be made from this ongoing project, acknowledging that it is still in the early stages of digital tools implementation, with limited lessons learned at this point:

- **Effective planning and thorough understanding of the landscape prior to digital tools implementation**. It is important to assess the varying levels of awareness and competing interests among stakeholders—such as government, developers, and financiers—regarding data and digitalization in the minigrid sector. This is why sector-specific digital readiness assessments were included at the national level in AMP. Extensive consultations are crucial for aligning expectations, building consensus, and ensuring that digital solutions are adequately integrated and supported across the sector.
- **Balancing standardization with customized national solutions.** While standardization is essential for ensuring interoperability and scalability, it is equally important to develop tailored digital solutions at the national level that align with these standards. Additionally, a holistic approach is crucial in creating linkages between the various aspects of minigrid deployment supported by digitalization—such as planning, tendering, operations, and monitoring—to maximize synergies and enhance overall system integration.

Recommendations for other regions or countries considering similar initiatives are yet to be documented in future publications, as more time is needed to assess how these approaches work in practice. Additionally, identifying priority investment areas and providing insights into future mini and micro-grid policy support, particularly in rural and high-energy-burden areas, remains an important task.

Further research is also required as to how minigrids could benefit from local energy trading and trading between different minigrids, including identification of obstacles that will likely include insufficient asset-level measurement data required to enable these new business models that can further harness the local energy potential.

Energy vulnerability reduction fund and smart metering (Republic of Moldova)

Background and context

Energy landscape in the Republic of Moldova is marked by significant challenges, primarily due to its heavy dependence on energy imports.

In 2022, the Republic of Moldova faced a substantial increase in gas prices due to tightening global energy markets and a newly amended contract with its gas supplier, Gazprom. During the heating period, the Republic of Moldova purchased gas at prices approximately three times higher than in previous periods, a surge which put considerable strain on public finances and on the ability of the most vulnerable households to afford gas throughout the winter. The rising gas prices created a domino effect, driving up the cost of other goods and increasing the risks of not only energy poverty but also food poverty in both rural and urban areas of the Republic of Moldova.

The energy crisis compounded the challenges posed by the COVID-19 pandemic and the associated health crisis, which had significantly impacted the economy of the Republic of Moldova, resulting in a 5% drop in GDP in 2022, all while 31.1% of the population was living below the national poverty line.

The war in Ukraine further deepened the energy crisis and has led to a 30% reduction in gas supply and a price increase combined with high inflation rates. The Republic of Moldova was further impacted by the attacks on the electricity generation facilities in Ukraine, which were covering approximately a third of electricity demand of the Republic of Moldova.

As a result, in 2022, more than 71% of the households in the Republic of Moldova were in the most vulnerable energy category and the early income simulation by UNDP suggested that, under the prevailing food and energy inflation levels, approximately 250,000 people were at risk of falling below the poverty line. These circumstances have placed energy vulnerability and poverty at the forefront of policy debates in the Republic of Moldova.

Digital initiatives

Energy Vulnerability Reduction Fund

To address the urgent energy crisis in the Republic of Moldova, the Government, with technical support from UNDP, designed and implemented the Energy Vulnerability Reduction Fund (EVRF, Law 241/2022) – an evidence-based, on-bill compensation scheme to minimize the negative impact of energy inflation on households.

The objective of EVRF is to compensate energy-poor and vulnerable households for the increase in centralized heating, natural gas, and electricity tariffs, with the overall aim to create an inclusive solution that minimizes the negative impacts on energy-vulnerable and income-poor households, therefore safeguarding social cohesion. At the same time, in the longer term, EVRF aims to incentivize the transition towards sustainable energy sources and to achieve higher levels of energy efficiency in the residential sector.

A digital platform to register and process requests for on-bill compensation for energy-related expenses was put in place and launched in October 2022.[6] The registration process was implemented using a simple administrative procedure, relying on administrative data, and requiring minimal confirmation from beneficiaries. The system balanced targeting efficiency with a reduced administrative burden, ensuring that even those who did not register received compensation by default under the low energy vulnerability category. This inclusiveness was foundational to the architecture of EVRF, ensuring substantial coverage of the poor and vulnerable.

EVRF offered on-bill compensations for 895,000 households during the 2022/2023 heating season (75% of households in the Republic of Moldova) and for 757,600 households during 2023/2024 (preliminary data).

While most of the funding was provided directly to the Government of the Republic of Moldova by the European Union, nearly USD 30 million was channelled through UNDP interventions funded by Sweden, Switzerland, and Italy. To bridge the digital divide, UNDP established a dedicated Support Unit within the Ministry of Labour and Social Protection to provide in-person, online, and phone consultations to the beneficiaries of EVRF.

Smart metering infrastructure pilot for electricity

An important initiative involves installing smart meters to enhance energy flow monitoring, identify commercial losses, improve distribution quality, and reduce operational costs.

The pilot initiative, led by the Ministry of Energy of the Republic of Moldova with support from UNDP Moldova and the Italian Government, aims to install 35,000 smart meters across the country, representing approximately 3% of the total electricity consumers in the Republic of Moldova.

The initiative began with the installation of 3,000 smart meters in Chișinău and its suburbs. These initial installations were carried out by system operators, Premier Energy Distribution in Chișinău and six suburbs, and by RED Nord in the northern region, including Bălți. The initiative has since expanded to cover additional regions, including rural areas.

The households selected for this pilot are chosen based on criteria such as geographical location, population density, energy vulnerability, socio-economic status, and infrastructure availability.

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[6] Online application platform for the EVRF energy compensation programme, available at: https://compensatii.gov.md/en#program

The smart meters measure consumption at short intervals, track energy quality parameters, and transmit data automatically and securely to the energy supplier, eliminating the need for manual readings by distribution company employees. This system ensures billing is based on actual energy consumption rather than estimates and allows distributors to identify and respond to accidents more swiftly. The system's ability to gather real-time remote data facilitates the development of dynamic pricing models aimed at optimizing consumption patterns.

Smart meters also enhance grid security by swiftly detecting irregularities, from minor faults to major outages, allowing for rapid response and minimizing downtime. The detailed consumption data gathered enables more efficient energy resource management, preventing grid overloads and optimizing supply to meet demand.

The smart metering infrastructure employs Power Line Communication technology, which uses power lines and electronic communication operators to transmit data to a central unit for analysis. This centralized data will help monitor consumer behaviour relative to energy prices and aid in policy development.

These meters provide critical technical information that enhances the monitoring of energy flows, identification of commercial losses, and quality of distribution services, while reducing operational costs and impacting electricity distribution tariffs.

In Bălțiul Nou, RED Nord has also replaced overhead power lines with underground networks to improve safety. With smart grids, customers can choose flexible tariffs, and smart appliances can automatically read tariffs from the meter to optimize usage times. Data from this programme will inform new policies for efficient consumption, and the UNDP and EU are exploring technical solutions for nationwide application, including smart meter installation and the “Rabla for household appliances” programme.

Lessons learned

Since its operationalization, EVRF successfully reached a broad spectrum of households, significantly alleviating the financial burden of energy costs for vulnerable families in the Republic of Moldova, allowing these households to allocate resources to other essential expenses, thereby improving their overall quality of life.

According to the 2023 UNDP impact assessment of EVRF,[7] the compensations reduced the level of energy poverty by 43% and had the greatest impact on the most vulnerable families. The results of EVRF are confirmed by the recent economic update of the World Bank,[8] which concludes that EVRF reduced the potential poverty impact of energy price shocks by 8 percentage points (limiting the increase in poverty rate from 28% pre-crisis – to 35%, versus 43% without EVRF).

[7] UNDP Moldova, September 2023, The Impact Assessment of the Energy Vulnerability Reduction Fund in the Winter of 2022–2023, available at: https://www.undp.org/moldova/publications/impact-assessment-energy-vulnerability-reduction-fund-winter-2022-2023

[8] World Bank, April 2024, Moldova Economic Update. Special section: Energy affordability, available at: thedocs.worldbank.org/en/doc/d1372d2b12612d7eb259fa07d6270de7-0080012024/original/Moldova-Economic-Update-2024-ENG.pdf

These outcomes were achieved through substantial policy and programmatic support from UNDP, based on a timely assessment of energy poverty conducted in early 2022.[9] The evaluation provided critical insights and recommendations for EVRF, highlighting the need for a more integrated and nuanced approach. It emphasized the importance of establishing robust data governance frameworks and enhancing internal evaluation capacities to ensure data integrity and accuracy.

The journey of the Republic of Moldova towards European Union integration presents both challenges and opportunities in the energy sector, particularly in enhancing energy efficiency and security while improving services for all citizens, especially vulnerable groups. The focus for the continued support shall be on addressing energy security and poverty, promoting comprehensive, co-designed solutions that consider the interconnectivity and feedback loops shaping the future of the energy sector in the Republic of Moldova.

Forward-thinking solutions include the digital transformation of the energy sector, energy efficiency, decarbonization policies, and energy-saving technologies. These initiatives will involve experimenting with new business models, expanding energy sandboxes, promoting renewable energy, supporting community-owned renewable energy cooperatives, fostering public-private partnerships, and securing sustainable finance for renewable energy and climate-resilient infrastructure.

These examples underscore that digital transformation is not just about providing access but also about ensuring that access leads to meaningful improvements in people's lives.

Building on the successes and lessons learned from EVRF, efforts will focus on enhancing its impact by integrating the approach into a broader, digitalized national social protection system. Establishing a robust Data Governance Framework is essential for managing data assets, ensuring consistency, security, and reliability across all levels of governance, and sustaining the momentum of digital transformation to achieve long-term, system-wide improvements. This strategic approach, has the potential of streamlining processes, enhancing service delivery, and improving decision-making through real-time data analytics.

The prosumer model (Lithuania)

Introduced in 2019, innovative prosumer scheme allows consumers in Lithuania to produce their own electricity, contributing to the country's electricity grid, thereby enhancing energy security, promoting RES, and supporting climate change mitigation efforts. This example offers valuable lessons on integrating principles of energy governance into practical, actionable policies. By focusing on innovation, flexibility, and inclusivity, Lithuania not only advances its own energy security but also contributes to global environmental goals.

Key features and systemic innovations

The approach taken in Lithuania includes several pioneering features:

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[9] UNDP Moldova, September 2022, Report on Energy Poverty Assessment and Support Mechanisms in the Republic of Moldova, available at: https://www.undp.org/moldova/publications/report-energy-poverty-assessment-and-support-mechanisms-republic-moldova

- Nation-wide remote production and (self)consumption: The grid functions as a 'virtual battery,' storing and distributing energy nationwide;
- Digital accessibility: Becoming a prosumer is streamlined through digital platforms, simplifying the process and eliminating paperwork;
- Subsidies while prioritizing private investment: Initial subsidies (approximately 30% for installation costs, capped at certain amount per kilowatt peak) helped kick-start the scheme, which is primarily driven by private investments.

Regulatory framework and strategic goals

In 2019, the Government of Lithuania set ambitious targets to reach 510,000 prosumers by 2030 and 750,000 by 2050, which would constitute 30% and 44% of all energy consumers respectively. These targets are supported by an evolving legal framework that progressively broadens the opportunities for both local and remote prosumers, facilitating the adoption of various RES technologies and removing previous capacity restrictions.

As an example, back in 2015, a country-wide quota of 10 MW for cumulative capacity of prosumer solar installations was set. The quota was lifted to 100 MW in 2018, then to 200 MW in 2019, and finally virtually removed altogether later. At the beginning of 2024, cumulative capacity of installed prosumer solar photovoltaics (PV) stood at 1024 MW, with more than 100,000 consumers enjoying prosumer status. Among them, 86 000 were households and 16 000 were legal entities (schools, hospitals, small and medium enterprises and large businesses, etc.).[10]

Support mechanisms and community engagement

Support for prosumers and other similar RES support programmes is robust, with EUR 800 million allocated for the fiscal period of 2021-2027.[11] This support extends to various models of prosumer setups, including on-the-spot and virtual power plants, ensuring flexibility and inclusivity. Community campaigns and projects funded by the European Union, further engage consumers in adopting RES technologies. One such project, led by the Lithuanian consumers alliance under the Horizon 2020 programme, was focused on communication and involvement of wider society, including those living in multi-family apartment buildings.

The project culminated with a collective purchase campaign, as citizens, combining their purchasing and negotiating power together, were able to purchase on-site or remote solar PV installations for a considerably better price.

The fast adoption of prosumer model was made possible thanks to a combination of factors: most families own a computer at home, have internet access, and have appropriate digital skills. Therefore, there was no issue to get people onboard via digital channels. Thus, the whole prosumer scheme was designed and implemented as a fully digitalized from the very beginning.

[10] See: https://enmin.lrv.lt/lt/naujienos/gaminanciu-vartotoju-jau-daugiau-kaip-100-tukstanciu/

[11] See: https://enmin.lrv.lt/lt/naujienos/energetiniam-savarankiskumui-ir-efektyvumui-rekordinis-paramos-kiekis/

This example shows how digitalization enables further development in the energy sector, including net-metering system for households and use of the grid as a virtual storage.

Challenges and future directions

As the prosumer scheme evolves, it plays an ever-increasing role in national energy security and climate policy. Plenitude of the consumer-produced electricity becomes an issue for the distribution grid, which must cope with disbalances in energy supply, storage, and demand. The ongoing multi-stakeholder interaction necessitates continuous adaptation by the Government of Lithuania of regulations to support technological and market developments in the energy sector.

Despite the visible progress, challenges such as technological integration, infrastructure development, and public acceptance remain. Addressing these will require ongoing policy adaptation, increased public-private partnerships, and sustained educational efforts to raise awareness about the benefits of RES and prosumer models. On a positive side, the latest innovations allow prosumption of not only self-produced solar energy, but also wind energy.[12] With this fresh impetus, the number of prosumers may further grow.

Even if the model of tariff support will move away from net-metering (for solar PV) to net-billing (for wind energy and ultimately for solar PV), the price differential between self-produced energy and grid-sourced energy creates a powerful incentive to become a prosumer. While the Government of Lithuania has rolled back from its target to reach 510,000 prosumers by 2030 to a less ambitious one, 300,000, this systemic innovation model remains promising.

The next leap would be to advance the legislation related to energy communities, moving from self-consumption schemes to peer-to-peer trading and eventually allowing trading between communities to further align local generation and consumption and increase the return and therefore the overall individual investment in renewable and flexible assets.

[12] See: https://www.lrs.lt/sip/portal.show?p_r=35435&p_k=1&p_t=287123

Policy approaches for governance of digitization and digital transformation in the fuel and energy complex (Russian Federation)

Background and context

The rapid advancement of digital technologies, including AI systems, service platforms, and big data, presents new challenges and opportunities for Russian society. This shift is propelling the Russian Federation into a new phase of development across all sectors, including the energy industry. Unlike previous periods, society now demands faster adaptation to new technologies, along with improved quality, efficiency, and security in the energy sector – the objectives that can only be achieved through comprehensive digitalization.

National goals and programme

The Russian Federation places significant emphasis on supporting digitalization and digital transformation, addressing the challenges faced by the information technology (IT) sector. This includes the development of an electronic component base, the promotion of domestic research and development, and the enhancement of IT education.

In line with the Government's digitalization policies, it is crucial to highlight the establishment of a hierarchical system of interconnected strategic planning documents in the Russian Federation. This system ensures the continuity of objectives, aligning tasks with available resources. Industry-specific strategic planning documents, including those related to digitalization and digital transformation, are grounded in these overarching national planning frameworks.

Digital transformation has been designated as one of national development objectives of the Russian Federation until 2030 and for the perspective until 2036. This priority is outlined in the Presidential Decrees No. 474 "On National Development Objectives of the Russian Federation for the Period Until 2030", dated 21 July 2020, and No. 309 "On National Development Objectives of the Russian Federation for the Period Until 2030 and the Perspective Until 2036", dated 7 May 2024, both being key documents for strategic planning at the Federal level. Consequently, measures and projects aimed at achieving the national digital transformation goals are integrated into relevant industry-specific strategic plans, Government programmes, and national projects.

One of the key initiatives designed to achieve this national development objective, is the National Programme for the "Digital Economy of the Russian Federation". This programme focuses on enhancing the regulatory legal framework, information infrastructure, human resources for the digital economy, information security, digital technologies, and digital state governance. In 2024, underway towards completion of this National Programme, the President of the Russian Federation issued directives to establish a new national project entitled "Economy of Data and Digital Transformation of the State", which envisages continued implementation of measures aimed at achieving the indicators of the national development objectives related to digital transformation.

In the energy sector, one indicator of progress toward the national development objective in digital transformation is the achievement of "digital maturity" in key sectors of the economy and social sphere, including public health, education, and state governance. This indicator specifically includes the attainment of "digital maturity" for energy infrastructure.

Strategy of digital energy transformation

As part of this indicator and to achieve the set digital transformation goals, the Government of the Russian Federation has approved strategic directions for the digital transformation of key economic sectors, the social sphere, and state governance. This includes the strategic vector for digital transformation in the fuel and energy complex (FEC) until 2030 (hereinafter referred to as SV DT FEC).

The objective of SV DT FEC is to achieve a high level of "digital maturity" among the FEC key players, and to accelerate the transition of the energy sector of the Russian Federation to new managerial and technological levels, thereby promoting technological sovereignty. This transition will create favourable conditions for the development of FEC and will support the long-term sustainable socio-economic development of the Russian Federation. This will be achieved by optimizing and transforming business processes through the use of common information models, "end-to-end" digital technologies, and platform services, all within the context of rapidly changing external and internal factors.

As part of SV DT FEC, the key priorities, tasks, challenges, and strategic vectors for the digital transformation of FEC have been outlined. The main priorities identified include:

- Platformization: Developing unified approaches to structuring the architecture of information systems;
- Implementation of digital transformation: Focusing primarily on utilizing domestic technologies;
- Introduction of unified standards: Establishing standardized information exchange protocols and uniform regulations for interaction between different systems and stakeholders;
- Optimization of service delivery: Optimizing and streamlining the processes of providing services within FEC;
- Active utilization of digital platforms: Notably, leveraging the GOVTECH Unified Digital Platform.[13]

SV DT FEC also includes industry projects aimed at shaping a unified state policy for developing FEC digital platforms. These projects focus on creating conditions that support the replacement of imported software across critical energy information infrastructure within FEC. Additionally, they promote the introduction and development of AI technologies within the sector.

In addition to specific projects, SV DT FEC outlines prospective activities for the digital transformation of FEC of the Russian Federation. These activities consider the strengths,

[13] https://platform.gov.ru/en/

weaknesses, opportunities, and threats specific to the Russian FEC in the context of digital transformation. Key activities include:

- Introduction of digital systems: Implementing systems to balance energy consumption more effectively;
- Data-driven governance: Transitioning the industry to management practices based on high-quality, up-to-date, relevant, accurate, and authentic data;
- Monitoring and maintenance**:** Deploying digital systems to monitor equipment status, shifting from unscheduled and routine repairs to condition-based maintenance;
- Adoption of cloud computing: Encouraging widespread use of cloud computing within FEC organizations;
- Collaboration and knowledge sharing: Enhancing cooperation among Russian FEC organizations to share and replicate developments in "end-to-end" digital technologies;
- Increased investment in research and development: Boosting funding for research and development in "end-to-end" digital technologies, particularly in production control and lifecycle management of energy facilities;
- Strengthening information security: Introducing and enforcing stringent information security requirements at the legislative level;
- Development of tailored IT solutions: Creating IT solutions for tracking logistics and trade operations within the FEC;
- Standardization of IT requirements: Unifying requirements, including the development of methodological guidelines for describing information and communication technology architectures;
- Integration with science and education: Promoting collaboration between FEC organizations with the science and higher education. This includes research, development, and engineering activities related to FEC projects, as well as updating curricula, state educational standards, hands-on training, and internships to ensure students engage with industry-relevant topics and receive practice-oriented training in partnership with FEC organizations.

SV DT FEC will serve as a guiding document for regional authorities and industry companies in developing their own digital transformation strategies, programmes, and measures.

Advancement of research and development in the corporate sector

To shape a systemic approach for companies with Government participation in implementing digital transformation projects, including import substitution in the energy sector, the Government of the Russian Federation issued Directive No. 3438p-P13 dated 14 April 2021. This directive requires companies with Government participation, including those in the energy sector, to develop and implement digital transformation strategies and programmes. These documents should contribute to achieving the planned indicators of "digital maturity".

Given that the Russian FEC includes large vertically integrated companies with extensive research infrastructure and in-house capabilities for developing digital products, the Government is establishing Industrial Competence Centres (ICC), such as ICC Electroenergetica and Neftegaz (Electric power industry and oil and gas), Neftechimia (Petrochemicals), and Nedropolzovanie (Subsoil use). These centres play a crucial role in replacing imported industrial digital products and solutions with domestic alternatives. The primary task of ICCs is to identify the technological needs of various economic sectors and propose mechanisms for implementing and replicating domestic technologies. ICCs also facilitate coordination and collaboration among companies in developing and implementing digital products, helping to effectively address critical import substitution challenges. The Government may co-finance ICC projects to support implementation of their projects.

As part of their activities, ICC Electroenergetica, Neftegaz, Neftechimia, and Nedropolzovanie have already selected 36 significant projects, some of which are currently being implemented. The IT products developed in the framework of implantation of these projects, are expected to have export potential.

Use of Artificial Intelligence technologies in selected fuel and energy sectors and related information systems

In the Russian Federation, AI technologies are considered "end-to-end" digital technologies, meaning they can be applied across all sectors of the economy, including the energy sector. Since 2019, the foundational National Strategy for AI Development, covering the period until 2030, has been implemented by energy companies, serving as the primary framework for their AI-related action plans.

The AI initiatives mandated by the President of the Russian Federation are integrated into Government schemes and national projects. In this context, the Russian Ministry of Energy, through its ministerial project "Digital Energy Sector" – a key component of the Government programme "Development of the Energy Sector" – has developed action plans. These plans include regular industry workshops to assess the AI technology needs of FEC companies and to implement measures that address these needs, including engaging small technology companies and start-ups.

At the same time, the energy sector is making rapid advancements in the use of AI technologies, with AI recognized as a strategic priority. This focus is reflected in the significant increase in investment in AI-related projects. Additionally, AI action plans are incorporated into the digital transformation strategies and investment programmes of companies with Government participation, as directed by the President of the Russian Federation. This is particularly important for the energy sector, where companies with Government participation hold a significant share in both the electric power and oil and gas industries. By 2024, these FEC companies have already invested over RUB 2.6 billion in AI projects. According to projections, the implementation of AI is expected to contribute, cumulatively, an additional RUB 11.2 trillion to GDP of the Russian Federation by 2030. Given that the FEC generates about one-fifth of national GDP, the impact of AI on the energy sector alone could result in hundreds of billions of rubles being added to the GDP on an accrual basis by 2030.

Among the sectors of the economy, the energy sector holds one of the highest potentials for AI utilization due to the unique characteristics of this technology, particularly its reliance on vast data sets for development. In FEC, the annual volume of data generated amounts to thousands of petabytes, which is several times greater than in industries like retail or social media. Moreover, studies conducted in 2023 show that FEC ranks second among all economic sectors in terms of data availability for AI development and use.

In 2023, 40.6% of organizations within the Russian FEC were already using AI to varying degrees, with 20.2% reporting that the impact of AI on their operations is significant or transformative. Additionally, 18.1% of organizations in the sector plan to adopt AI within the next three years.

Oil and gas industry

The implementation of AI in FEC has yielded significant results. For instance, in the Russian oil and gas sector, a project focused on intelligent support for decision-making has optimized the development of oil and gas fields. This project enables the effective arrangement of new wells and the selection of operating modes for existing wells through three-dimensional modelling. According to projections, the benefits of this project at two pilot oil and gas fields are expected to exceed RUB 500 million over five years. In one field, the project is projected to increase oil production by 8% and profits by 11%.

AI models have also been developed to predict downtime in electric centrifugal pump installations based on data analysis, allowing for timely repairs. Over three years, this project has increased the interval between repairs by 20% and reduced oil loss during work shifts by half.

AI is also being used to assess the risks of emergency and pre-emergency situations during well drilling. AI algorithms analyse data from geological and engineering surveys, identifying patterns similar to those preceding emergencies. They classify the drilling process as either normal or at risk of complications. These algorithms can predict emergencies such as drill assembly sticking, drilling mud loss caused by geological formations, drill column failure, drill stem washout, balling-up, and gas, oil, or water shows. In one specific project, the use of this technology reduced the accident rate in wells by 15%, preventing 50-60 incidents of varying severity per year.

Electricity industry

In the electricity industry in the Russian Federation, AI technologies are being introduced to enhance consumer service. Voice assistants (AI consultants) equipped with speech recognition and synthesis functions, are starting to be deployed. These systems have reduced the percentage of unserved user calls from 30% to 10% in some cases. For certain projects, up to 60% of incoming calls related to power outages during major grid disruptions can be handled without operator intervention. Additionally, there has been a noticeable decrease in the average time required to process user calls about scheduled and emergency power cuts.

AI technologies are also utilized for precise forecasting of electricity generation at power plants, particularly for those dependent on weather-dependent renewable energy sources.

Furthermore, to prevent offenses in the electricity sector, a project is underway that uses AI to forecast the probability of unaccounted-for electricity consumption at supply points. This project assesses the likelihood of detecting unreported consumption based on computer modelling and the analysis of large datasets, including over 300 logic chains and decision trees. As a result, the efficiency of verifying electricity metering has improved by 4 to 6 times.

Coal industry

AI is significantly enhancing various processes in the coal industry, including improving industrial safety. For example, AI solutions utilizing computer vision detect connection joints on conveyor belts and monitor the number of metal rivets at these junctions. This technology has led to a 20% reduction in emergency shutdowns caused by belt cloth ruptures.

Additionally, AI systems are used to monitor the technical condition of hydraulic equipment. The AI system collects data every 30 seconds and identifies deviations from normal operation, alerting mechanics if there is a risk of an emergency. Full-scale implementation of this approach, which supports condition-based maintenance, is a key priority for digital transformation across the coal industry and the broader energy sector.

Moreover, pilot projects are underway in the Russian Federation to use AI for monitoring the use of personal protective equipment by production personnel. Neural networks analyse video footage from production sites to identify instances where safety requirements are not being followed.

State information systems

Several federal state information systems have been established and are operational in the Russian Federation to support Government decision-making, digitize services, and manage state, municipal, and regulated organizations.

One key system is the State Information System of the Fuel and Energy Complex (SIS FEC). This federal system provides comprehensive information and forecasts regarding the development of FEC in the Russian Federation. SIS FEC aims to enhance interaction within FEC and create a unified state information space to support management decisions and their implementation, including in related economic sectors. Notably, SIS FEC also includes components focused on energy saving and improving energy efficiency.

The creation, operation, and enhancement of SIS FEC are governed by Federal Law No. 382-FZ "On the State Information System of the Fuel and Energy Complex", dated 3 December 2011. SIS FEC is designed to automate the collection, processing, storage, access, dissemination, and distribution of information related to FEC. It aims to improve the efficiency of information exchange regarding the status and future development of the FEC.

Federal executive authorities, primarily the Ministry of Energy, along with authorized state institutions, regional executive bodies, legal entities, and private entrepreneurs involved in various aspects of energy resources – from extraction and production to distribution and commercial infrastructure – are integral to these processes. The Russian Energy Agency, part of the Ministry of Energy, is the operator of SIS FEC.

Currently, over 2,500 FEC organizations contribute data for integration into the system, which supports the informational and analytical needs of the Russian Ministry of Energy. The obligation to provide this information is established by the "Regulations on the Mandatory Provision of

Information for Incorporation into SIS FEC”, approved by the Government of the Russian Federation in its Resolution No. 1384, dated 22 December 2012.[1]

To inform and support state policy, a state information system focused on energy efficiency (SIS Energy Efficiency) has been established. This system has been upgraded and currently includes a Register of Greenhouse Gas Emissions. A Register of Carbon Units, which utilizes public-private partnership tools based on a federal concession agreement with a private company, has also been introduced.

In addition to these systems, significant contributions to the digitalization of services and the enhancement of information quality and interaction are made by SIS for housing and communal facilities and for industry. The latter is crucial for managing subsidies to industrial organizations, including those for developing energy-saving products and components. These SIS interact through a system for inter-departmental electronic document exchange.

Russian constituent entities also develop their own regional systems, leveraging both local innovations and scalable solutions proven in other regions. Typically, these regional systems are more integrated with local energy consumption planning and management processes, extending to budgetary institutions and communal enterprises. They include functionalities such as facility passports, integration with the federal system, resource accounting and control tools, and support for action plans, projects, and programmes. A notable example of successful implementation is the system in the Belgorod Region, developed by a local technology institute and implemented by the regional agency for energy efficiency. This system has led to savings of RUB 741 million from the region's budget since 2019 and has stimulated investment in energy efficiency initiatives.

Effects, lessons learned, and long-term plans

A hierarchical system of strategically linked planning documents has been established to ensure continuity in achieving goals, balanced with clear objectives and their necessary resources. This structured approach supports both technical and economic advancements, as well as social benefits.

Key technical and economic effects of this hierarchical system, include:

- Platformization: Development of unified approaches for building the architecture of information systems;
- Optimization of service delivery: Improvement of processes in FEC;
- Digital systems for energy consumption: Implementation of systems to balance energy use efficiently;
- Data-driven management: Transition to asset and operation management based on high-quality, up-to-date, and reliable data;
- Condition-based equipment monitoring: Introduction of digital systems for monitoring energy equipment, shifting from unscheduled repairs to those based on its technical condition;
- Cloud computing: Broad adoption of cloud computing by FEC organizations;

- Enhanced cooperation: Promotion of collaboration among FEC organizations to replicate their advancements in “end-to-end” digital technologies;
- Increased funding for research and development: Investment in research and development of “end-to-end” digital technologies, including those for production management and life cycle management of energy facilities;

Long-term plans envisage:

- Development of electronic component base (expansion of in-house research and development) and enhancement of IT education;
- Achievement of “digital maturity” across key economic and social sectors.
- Achievement of carbon neutrality;
- Meeting the targets set for national digital transformation objectives.

Conclusions and general policy recommendations

Digitalization is characterized by the transformative impact on energy systems and governance. Digital tools are essential for enhancing efficiency, transparency, and stakeholder engagement, making them key drivers of a successful energy transition, as well as the move towards carbon neutrality. However, the integration of these technologies also introduces challenges, particularly related to data privacy and cybersecurity. Addressing these complexities requires robust governance frameworks that not only maximize the benefits of digital transformation but also ensure that digital technologies are implemented responsibly, ethically, and inclusively.

Effective governance is central to the successful digitalization of energy systems. It safeguards data privacy and security while promoting transparency and inclusivity, enabling active participation from all stakeholders in the energy transition. Additionally, ensuring economic viability through targeted incentives is crucial for encouraging investments in digital technologies. To support this process, the following policy recommendations are proposed:

1. **Develop comprehensive regulatory frameworks**: Governments should establish clear policies and standards that promotes the adoption of digital technologies and practices while also addressing the emerging challenges, including cybersecurity, data privacy, and ethical technology use. Regulatory testbeds should be encouraged and the process for innovators to transition from testing and demonstrations to mainstream regulation should be rendered more transparent and efficient.
2. **Promote inclusive stakeholder engagement**: Encourage active participation from all stakeholders – local communities, industry players, and civil society – to ensure that the digital transformation efforts of energy transition are inclusive and meet diverse needs.
3. **Invest in capacity-building**: Strengthen the capabilities of public institutions and stakeholders to manage digital energy systems effectively through targeted training and education programmes focused on digital skills, taking into account that local digital developments can demonstrate significant efficiency compared to imported ones.
4. **Facilitate economic incentives for digitalization:** Establish regulatory frameworks that encourage investment in digital technologies that increase system transparency and interoperability and enable new business models based on improved access and higher granularity of energy data. This strategy is essential for recognizing the value of digital investments and ensuring long-term accountability and sustainability.
5. **Foster international collaboration**: Encourage countries to share knowledge and collaborate on digitalizing energy systems. Joint economic and policy studies and other types of partnerships can highlight successful funding policy mechanisms and investment strategies, fostering innovation and best practices.
6. **Ensure continuous monitoring and evaluation**: Implement mechanisms for ongoing assessment of digital initiatives to promptly address challenges and adapt strategies, improving governance practices over time.

By adopting these recommendations, governments and policymakers can navigate governance challenges and fully leverage the opportunities presented by digitalizing energy systems, leading to a more resilient, efficient, and inclusive energy future.