wennovate

D5.1 List of Recommendations for the Action Plan with Buy-in from Stakeholder Dialogue

August 2024

Deliverable data

WEnnovate factsheet	
Grant Agreement No.	101134909
Project Acronym	WEnnovate
WP No.	WP5
Lead	GFO
Contributor(s)	All partners, reviewer: SSF
Due Date	M9 14th August 2024
Actual submission date	8 August 2024
Type	R-Document, report
Dissemination level	Sensitive/Public

Document History

Version	Date	Note	Partner
Version 1	8 July 2024	First draft	GFO
Version 2	2 Aug 2024	Second draft	All
Version 3	4 Aug 2024	Partner review	SSF
Version 4	6 Aug 2024	Formatting	GFO / DT
Version 5	8 Aug 2024	Final version	GFO

WEnnovate partners

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1. Introduction

1.1. Ambitions for the Action Plans

The WEnnovate project is on a mission to enhance deep tech and digital innovation ecosystems to drive the energy transition within the Netherlands, Hungary, Ukraine and Slovakia. To achieve this, we are co-creating a series of 4 national action plans and 1 joint cross-regional programme to support these innovation and energy transformations, with the help of key stakeholders (both established and under-represented) within these respective ecosystems.

Recognising the critical link between the energy and digital sectors, the foundation of our work is framed around facilitating fair, affordable, and decentralised energy systems, and understanding the role and challenges for innovators to drive this reality.

The action plans will create a roadmap for this transition with concrete actions, and supporting materials for change-makers, including documentation of knowledge assets (good practice), potential synergies, strategies and processes to drive the change. The plans will also address where possible practical considerations such as collaboration, planning and investment avenues for prioritised actions.

The programme will work with priority stakeholders to identify and pursue future funding and collaboration opportunities to realise the actions outlined within these plans.

This document outlines a series of key recommendations for the action plans at a joint-ecosystem, and national level. These include:

- the proposed structure of the plans
- an initial view of priority areas for each ecosystem
- format for documenting proposed actions and the required metrics / supporting information

These recommendations are developed out of a combination of initial desktop research and stakeholder engagement (interviews and workshops) and will continue to be reviewed with prioritised stakeholders.

2. Methodology

2.1. Proposed structure of the action plans and joint programme

During the initial desktop research, stakeholder engagement and analysis, a series of key themes stood out as recurring challenges, amongst all participating regions, for achieving the desired digital and deep-tech innovation driven energy transition and we chose these to create the framework around which to base the action plans. This framework consists of 6 action groups (Policy & Regulation; Market state & Funding; Human capital: Education, Awareness, Workforce; Technology Adoption & Deployment; Ecosystem Connectivity; Resilient Growth) and sub-groups within each of these. See the full framework in Fig. 1 below.

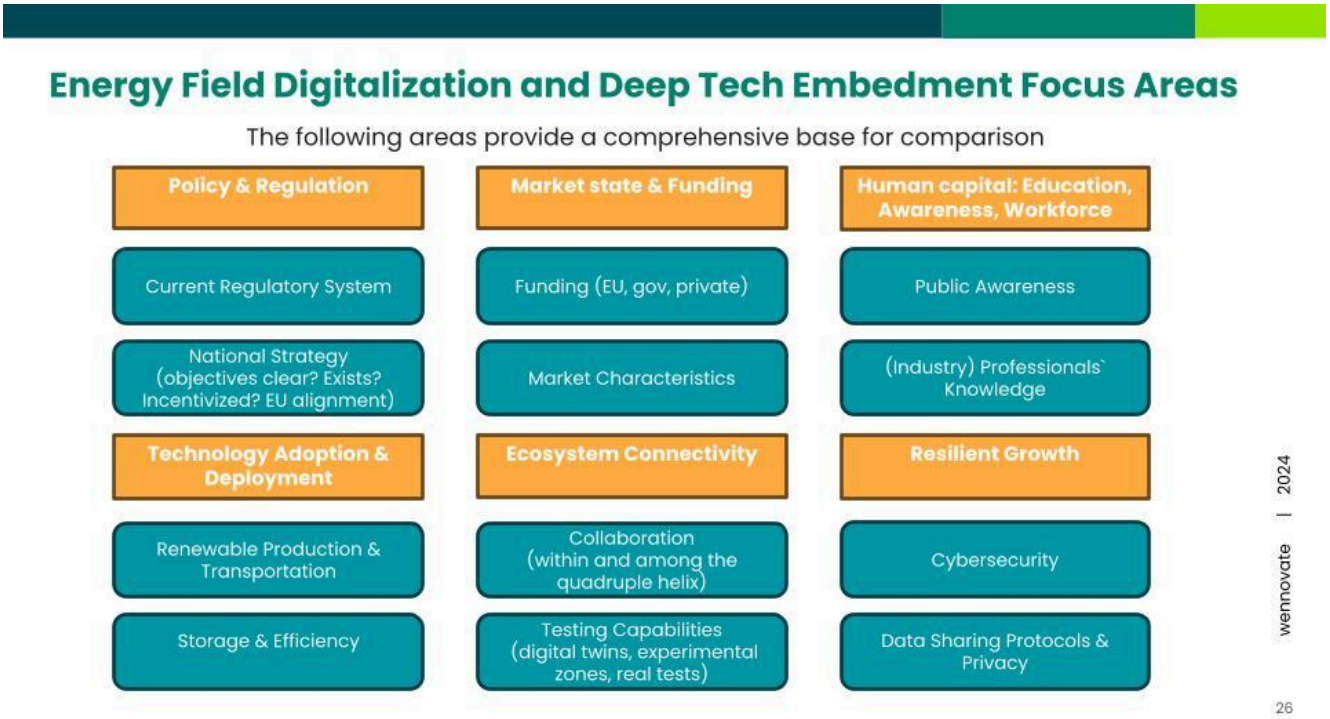

Figure 1: Action plan framework

This framework was also tested with the ecosystem stakeholders during the workshops and allowed us to identify priority areas for deep-dive sessions based on the regional priorities of each partner.

The framework has further been reviewed in-line with DG ENER's own Action Plan for the Digitalisation of the Energy System as well as local strategies and policies to ensure coherence with the broader ecosystem ambitions.

Regarding the structure of the action plans and joint programme, all 6 action groups and sub-groups will be addressed, with an array of specific and cross-cutting actions relevant for all parties as identified in the stakeholder engagement, research, and analysis activities.

Each action plan will consist of 4 parts:

- Executive summary
- Regional ecosystem overview (local policy context and strategies, innovation and energy transition maturity, existing good practice)
- Details of prioritised recommendations per ecosystem
- Annex with long-list of additional supporting actions

The joint-programme will mirror this with a similar but expanded structure:

- Executive summary
- European ecosystem overview (EU context and strategies, cross-cutting good practice)
- Cross-partner-ecosystem context: Existing synergies, collaboration and learning opportunities within participating ecosystems
- Prioritised cross-ecosystem actions
- Annex with long-list of additional supporting actions
- Communication and dissemination approach for ensuring uptake of action plans at joint-programme and national level

At both a national and joint-programme level, for each prioritised action, specific planning, investment, and stakeholder considerations will be taken into account and where possible, commitments will be incorporated into the resulting action plans.

2.2. Process for identifying recommendations

This document presents recommendations for the action plans in the form of a framework for the plans, the structure for each action, and the prioritised content for each ecosystem, and for the joint programme. The recommendations have been identified through analysis of both the desktop research and stakeholder engagement performed within the programme to date. As outlined above, each ecosystem has presented initial findings and relevant frameworks to stakeholders in the workshop sessions and this document acts as the cumulation of these inputs to date.

N.B. It is important to note that this is considered a live document. These recommendations are inputs to the deliverables D5.2 Joint action plans and D5.3 Joint-long-term programme plan and therefore will continue to evolve over the course of the activities planned for the remaining months of the programme, particularly regarding logistics for implementation of proposed actions stemming from the recommendations in this doc. As such, numerous fields regarding stakeholders, funding, timeframe, milestones etc. are either blank or TBC. These will be updated in the final document based on the outcomes of upcoming sessions. An additional long-list of further recommendations identified during the stakeholder engagement will be incorporated into the final deliverables as a separate but complementary document but is not included within D5.1.

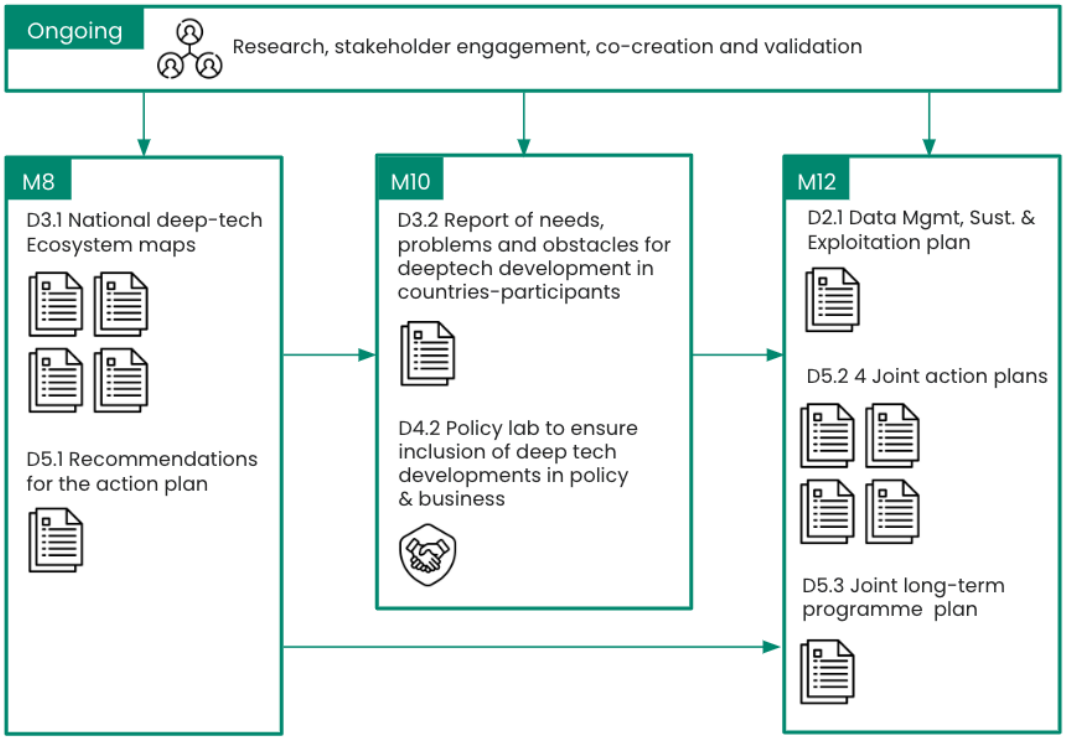

Figure 2: WEnnovate inputs to the Action plan deliverables

3. Recommendations for the Joint Long-Term Programme Plan

3.1. Analysis of synergies and action crossovers for joint action and collaboration

Despite the contrasting maturity levels and progress in the twin energy and digital transition of the four participating nations in the WEnnovate project (SK, UA, HG, NL), an initial analysis of the recommendations for the national action plans clearly demonstrates that there is significant overlap in the priority challenges each nation faces. As such, whilst acknowledging the inherent challenges that come with collaborating on an area of such strategic importance (a safe and secure energy system), we still see significant opportunity for joint action, collaboration, and shared learning on what measures are most effective in driving the twin transition and how key challenges can be overcome. These overlaps can be grouped into the following areas:

Recommendations on strategic vision, planning, and awareness:

All participants identified strategic gaps within the planning and vision for their respective national energy transitions, with **alignment to the EU's agenda** on the digitalisation of the energy sector a recurring missing link particularly at the national level. Aligning to an **EU wide coordinated approach** will maximise potential synergies and learnings that can be obtained between Member States and will leverage the latest know-how and technological advances available across the sector. Better **awareness** and **communication** of a coherent vision that unites society across the quadruple helix will be essential for building the momentum (public, private, and citizen) needed for this twin transition.

Recommendations on non-technological innovation and accelerating the uptake of existing digital energy technologies:

For all four nations, the digital technology required to support the energy transition is already largely available through the extensive catalogue of existing international (EU) or national solution providers. The key challenge is how these existing digital energy solutions can be **piloted** and deployed in **innovative contexts**, and then **scaled** via widespread adoption. The primary challenge is therefore a **societal,** and **commercial** one, reimagining the energy value chain and its historic business models to be fit for the future. Additionally, new technologies and alternative renewable energy sources should be deployed using a portfolio approach, leveraging existing and new **data**

sources to make strategic decisions for the transition roadmap. There is significant opportunity to have pan-European pilots demonstrating the value proposition of these existing new technologies in alternative contexts to set examples for SMEs, incumbents, and authorities alike on how the transition can be achieved and the accelerated benefits they can realise within this.

Recommendations on enabling technological innovation:

It should of course be noted that ongoing **technological innovation** (from distributed IoT energy assets through to centralised flexible grids) will continue to improve the EU's ability to accelerate and achieve the required transition, and this must be adequately **funded**, and **collaboratively** designed and engineered, with a focus on **interoperability** of future technologies

Recommendations on the legal and regulatory framework for innovation:

The required innovations (technological, societal, economic) will only be able to deliver on their potential if they exist within a system designed for purpose, with **regulation, principles, and incentives** that encourage their uptake and which are able to respond to ongoing evolutions in the transition in a timely manner, instead of delaying or preventing it altogether. Of particular importance will be the approach taken to **data** sharing and how this is leveraged privately and publicly to optimise the energy system and guide decision making. Likewise, with the proliferation of digital technologies, the associated cyber-security risks increase, and ensuring these are appropriately reflected within national frameworks will be key to a resilient transition which stakeholders have confidence in pursuing.

Recommendations on boosting collaborations and building international partnerships for the twin transition

The energy transition inherently cuts across all components of society, from individual households through to large industry and national infrastructure and from theoretical models to regulation and on-the-ground implementation. It is therefore imperative that this transition is characterised by widespread collaboration, at a cross-departmental, ministerial level, through to a **quadruple helix** model that brings together academia and industry, and end-users for solutions that are user-centric and will drive real scale, uptake and ultimately impact. Nations must ensure the **funding, spaces, incentives and cultural mindsets** are in place to drive this, and should embrace the possibility of learning from international peers going through, or having progressed past, similar challenges.

Recommendations on a skilled workforce fit to accelerate the twin transition

All of this will only be achievable if each nation's workforce and leadership are appropriately skilled and knowledgeable on the needs of the transition to guide and implement it. Education systems

and technical support programmes must be adapted to meet the needs of the transition, with an improved understanding of the role of energy in our society, and an appropriate offering of technical training available across all key components of the transition, from energy sources through to digital technologies, innovation, data , cyber-security and transition management. Sector experts must be integrated into the strategic planning of these workforce and education ecosystems to ensure they are designed to meet the needs of the future, not just the present. Building on this, education and awareness campaigns on the future of the energy system must be deployed EU wide to create a positive and attractive narrative for aspiring young people and those looking for new careers. Best practice based on existing behavioural studies and research should be leveraged to drive this mindset change.

Next steps

Throughout the course of upcoming stakeholder engagement, the above recommendations will be digested into concrete actions with the ambition of aligning on specific collaborations that respective national stakeholders are willing and able to take forward into implementation.

Particular attention will be given on how these cross-regional actions can be coordinated to ensure meaningful progress.

Actions will be categorised within the same framework model as the four underlying actions plans.

4. Recommendations for the action plan for the Netherlands

4.1. Status overview across action plan focus areas

The transition from fossil fuels to renewables, commonly referred to as the energy transition, represents the most significant shift in the energy landscape. This transformation is far more complex than simply swapping out power plants for renewable energy; it is a monumental change that fundamentally reshapes how we produce, trade and transport energy.

The Netherlands is a frontrunner in the energy transition and doesn't have many technological barriers. Almost all needed technologies are available. The challenge is in the societal change that it askes from end users, regulators, industry, energy companies and grid operators. The Netherlands needs to build an energy system that is much smarter and more interactive than it is today. Energy and resource efficiency, decarbonisation, electrification, sector integration and decentralisation of the energy system all require a tremendous effort in digitalisation. The EU action plan for digitalisation of the energy system overlaps with the recommendations we have received from key stakeholders. It’s about new skills for people working in the energy sector but also about leadership from their management. It's about rules and regulations that need to fit and facilitate the stakeholders right now so they can build the new energy system without always knowing yet what the end outcome will be. This asks for agile policy making with input from lessons learned in real projects and knowledge of cross sectoral experts, experts from the quadruple helix and in many ways less weight of incumbents trying to hang on to old business models or beliefs. Many places in the Netherlands should be a sandbox where experiments are taking place to learn how new technologies can be implemented taking into account adaptation by end-users, necessary incentives and principles for digitalisation.

This also means that the EU action plan on the digitalisation of the energy sector which is a much broader vision than just digitalisation, but is rightfully called this name, underlining the importance of digitalisation, should be campaigned in all member states. When the awareness of the route of the energy system is understood everyone will start working in that direction.

4.2. Prioritised recommendations for the action plan

4.1. Recommendations on Policy & Regulation

4.1.1 The role of digitalisation is still undervalued

Problem: Digitalisation is not valued at the vital role that it needs to play in the energy transition. The need and importance for digitalisation is seen by a select but growing group. Digitalisation is essential because renewable energy sources and electrification fundamentally change how we use electricity, necessitating for example much better demand-supply coordination. Without effective digitalisation, we risk needing very expensive grid enhancements. Digitalisation is also a key enabler of the EU's Energy Democratisation agenda. Digital tools not only enhance the efficiency and sustainability of the energy system and help manage distributed energy resources. Digital platforms can also empower consumers (citizens, communities, collectives) to become "prosumers".

Innovative companies with the expertise and skills to offer digital solutions are having a hard time accessing the market and implementing their solutions. The energy sector has a lack of knowledge of digitalisation, and the transition is still seen largely as building on the old instead of building the new energy system. EU policies that do understand the importance of digitalisation are not widely known and or implemented.

Recommendation 1.1: Make the EU action plan on the Digitalisation of the energy system top priority in The Netherlands Digitalisation of the energy systems (europa.eu).

Recommendation 1.2: Foster greater collaboration within and between ministries and stakeholders to build and adhere to a shared vision for the digitalisation of the energy sector.

Recommendation 1.3: Multiple stakeholders meetings (including a policy lab) aimed at developing a joint action plan containing a shared purpose, barriers, actions with the assignment of roles and responsibilities, timeline, budget, needed expertise, and a one-year deadline with evaluation and review (learning loop) to stimulate digitalisation.

Stakeholders: Ministries, ACM, TSO's, DSO's, regional government, top sector, VNO NCW, NP RES, Club van Wageningen, SSF, EnergieSamen, innovative companies from the IT sector.

4.1.2 Focus on building local energy systems and system integration

Problem: The EU energy agenda is clear about the future energy system, which has more regional planning, favours energy communities, more demand management, more monitoring of energy flows, and is built up with different energy carriers and storage. It is important that rules and regulations make shifting between different carriers and storage possible and viable. System integration is crucial for the energy transition, yet current regulations create barriers by treating gas, electricity, and heat under different laws. This fragmentation hinders the seamless shifting between different energy carriers and storage systems. If these systems were integrated, the business could optimise energy use by switching between grid electricity, wind power, and gas based on availability and cost. Current regulations make this difficult because they treat each energy source separately.

Recommendation 1.4: Ensure that rules and regulations make combining different systems, applications, or components into a single, unified system, where they function together as a whole, viable and possible. The new energy act should help this change. Test and evaluate in projects if it successfully facilitates these goals.

Recommendation 1.5: Create an openly accessible protocol for the exchange of energy between various assets by establishing parity between different carriers, representing them as assets in joules using a conversion index and communication protocol.

4.1.3 Digitalisation needs a new set of principles and regulation

Problem: With digitalisation, both hardware and software, playing a bigger role, the need for the right rules (principles) arises. Issues like "vendor lock-in," open source, privacy protection, cyber security, and interoperability will need attention. The lack of interoperable and open-source digital solutions leads to inefficiencies and vendor lock-ins within the energy ecosystem and also hinders innovation.

Recommendation 1.6: Update energy regulations to enable and foster digitalisation of the energy system. This includes setting up a standard reference architecture, ensuring interoperability, cyber security, and data structuring that supports the current and future developments on the previously mentioned criteria (governance). This also needs to be standardised in the EU to enable it to connect, share information, and hence share energy with countries.

Recommendation 1.7 Foster the development of interoperable, open-source digital solutions to ensure seamless integration and collaboration within the energy ecosystem. Find solutions to prevent vendor lock-ins, where one manufacturer’s device doesn’t communicate or operate with others, leading to a customer needing to buy other assets from the same manufacturer.

Use herein the "systems Dynamics modelling" approach which has been exercised in the EU INNOCYPES Project (ESR 14 & 15) to learn via feedback loop analysis [ph1] what the barriers for investments on digitalisation are.

4.1.4 Data sharing needs a new set of regulation and governance

Problem: The current data sharing and management practices within the energy ecosystem are inadequate, hindering the development of connected and responsive energy systems. Important difference to the old data approach:
1. Data Regulation was about market data used by energy providers. For this data consumers have ownership and abuse is easy. New data is system data which is about energy planning and optimising energy flows. This is needed by local and regional governments and corporations/energy hubs to plan and design local energy systems. It is of utmost social importance to predict unfavourable outcomes and or optimise energy use and balance supply and demand, which helps reduce grid congestion and the feed in of new renewables. This data is not primarily owned by consumers, but also by DSO's.
2. The amount of data coming from new technology will grow exponentially and current players ruling over this data won't be the ones in charge of it anymore.

Recommendation 1.8: Not all energy data is the same. Redefine the role of energy data and consider the social impact of its availability. Establish clear guidelines and rules for data sharing based on the specific source and role of the data, its accessibility, and intended use while taking into account cyber security and privacy risks. This approach will ensure responsible and equitable energy data management, maximising its benefits for end-users, industry and society while safeguarding privacy and security.

Recommendation 1.9: Enhance cross-sectoral data sharing and support more collaboration across other economic sectors. Energy data can also be useful for other industries like housing, transportation, and finance.

Recommendation 1.10: Build a special organisation, learning from other countries, that can use data to develop and manage open source tools needed for energy visions and energy planning. Interesting example could be the Independent Energy Data Centre Ltd. (FEAK) which was established in June 2023 as a support institution of the Ministry of Energy, whose main task is to develop and apply solutions for increasing security of supply and the wider use of renewable energy sources in the electricity sector. The company is providing professional analytical background for the decisions of industry players, energy communities and other users by processing and optimising large volumes of energy consumer data with the support of artificial intelligence. FEAK is establishing a centralised energy management framework for public institutions to ensure the efficient use of energy by implementing the necessary improvements.

4.2. Recommendations on market state and funding

4.2.1 Direction of policies, regulation and subsidies incentive the wrong path

Problem: Innovation in the energy market is driven by the (economic) outcome for the producer, consumer or market party based on the rules that have been created by people. Current market rules hinder the necessary (digital) innovation.

Recommendation 2.1. Create an innovation direction while creating new rules for those new innovations. Incentives are lacking or steering the wrong direction (net-metering/ salderen). Try out different incentives in pilots and learn from these pilots. Make sure end-users and innovative parties with a stake in a different energy system are part of the conversation.

And if DSO states (already for years) that they facilitate the market with their market facilitating services, they should expand/update this portfolio as the market is changing and new types of market parties arrive (energy communities). This should be mandatory as it is part of the facilitating framework in the CEP, REDII and EMD.

4.2.2 Favouritism of established players (funding)

Problem: Current subsidy programs tend to favour large, conventional energy companies, making it difficult for newer, smaller, and more innovative companies to compete and receive support. Writing proposals is highly labour-intensive and timing of the proposal writing coincides with the holiday season. This makes it impossible for smaller businesses to pre-invest in proposals. The rules for submitting are really strict so that even the smallest glitch on the part of RVO leads to exclusion which is a loss of months of investing work that smaller players can't risk.

Recommendation 2.2: Also select the non-conventional players for subsidies to make room for new innovative smaller players.

Recommendation 2.3: Develop and implement funding programmes specifically targeted at innovative energy solutions making use of a more entrepreneurial environment where failure is an option. Funding opportunities require a lot of detailed planning, however, there is also a need for options that bring together parties who may not have a fully defined outcome but use an innovative approach that will deliver needed insights that can only be learned through practical experience.

Recommendation 2.4: Offer compensation for innovative startups already while writing proposals to subsidy tenders. An issue smaller companies face with subsidy request writing, is that often they

have to write multiple, each taking weeks of work. Larger companies can fund this, but smaller companies don't have a budget for it.

4.2.3 Investing in Digitalisation and Modernisation

Problem: The current energy infrastructure is not yet modernised and lacks sufficient investment in social, digital and deep tech technologies, hindering the efficiency and effectiveness of the energy transition.

Recommendation 2.5: Increase funding and incentives for social and operational innovations alongside technological advancements in the energy sector.

Recommendation 2.6: Invest to expand and modernise energy infrastructure, especially with innovative, digital and deep tech technologies. Increase funding for digitalisation of the grid, adding IoT measuring devices to enable real-time supply and demand monitoring and bidirectional usage, known as smart grid tech. By integrating digital solutions, we can optimise the use of the existing grid and avoid the need for extensive new grid infrastructure.

Recommendation 2.7: Increase funding for projects that enhance data communication and independence between energy and telecom/internet networks. It is essential that the energy industry becomes connected to other sectors, like telecom, but this should be carefully planned to ensure independence and avoid chain reactions leading to multi-sector breakdowns.

4.3. Recommendations on Human capital, education, awareness, workforce

4.3.1 Addressing Workforce Shortage

Problem: There is a significant shortage of skilled professionals in the energy sector, with an estimated gap of 18,000 professionals. This shortage impacts the industry's ability to implement and manage energy transition projects effectively.

Recommendation 3.1: Address the workforce shortage by investing in technical training and recruitment initiatives. Make the energy sector an attractive, interesting, and rewarding industry to have a career in. Come with smart solutions which reduces the need for more infrastructure (which need 18.000 staff)

4.3.2 Shortage of skilled technical personnel

Problem: The current workforce in the energy sector doesn't always have the necessary skills and knowledge in digitalisation, decentralisation, and new technologies. There is also a need for continuous professional development to keep up with the rapidly changing energy landscape.

Recommendation 3.2: Develop and make workshops, hackathons, and continuous training courses on digitalisation available for energy experts. Additionally, amend energy-related university curriculums with digitalisation and decentralisation materials.

Recommendation 3.3: Implement comprehensive educational programs and master classes to upskill professionals in the energy sector about digitalisation, tokenisation, and new technologies.

Recommendation 3.4: Develop training programs focused on digitalisation and deep tech, especially on data governance and cybersecurity to equip the workforce with necessary skills.

Recommendation 3.5: Encourage the development of educational programs that focus on upskilling professionals in change and transition management and collaborative approaches.

4.3.3 Enhancing Public Awareness and Education

Problem: The general public lacks sufficient awareness and understanding of the energy transition and their role in it. This gap in knowledge hampers the adoption of community energy projects and the benefits of digitalisation and data-sharing.

Recommendation 3.6: Start communication on EU digitalisation agenda with focus on implementation, while reinforcing awareness about the benefits of important goals of the agenda like community energy projects.

Recommendation 3.7: Increase awareness programs to specifically highlight the benefits and importance of digitalisation, data-sharing, and behavioural change to make the public aware of the problems and how they can help the energy transition, while increasing their comfort and reducing costs.

Recommendation 3.8: Public awareness programs should focus on educating citizens about their role in the energy transition and the benefits of participating in decentralised energy systems. Educational programs and awareness campaigns can enhance understanding of the energy system among the general public and industry stakeholders. This will help them to make informed choices and ensure that they do not miss out on opportunities to become more competitive, or to save energy costs. For example, mastering digital skills will help SMEs and households to

understand how to engage in demand-response, how to optimise their own use of electricity produced on-site, or what is entailed by charging an electric vehicle.

4.4. Recommendations on Technology, Adaptation and Deployment

4.4.1 Protocols and interoperability (tech)

Problem: Current energy regulations in the Netherlands need updating to support the necessary digital transformation in the energy transition. A whole list has been made of issues that will hinder an inclusive, safe and reliable transition. These issues have to do with the lack of standardised communication protocols, preventing devices from working with those from other manufacturers. The lack of open standards and secure elements in energy devices limits interoperability and security across the energy value chain.

Recommendation 4.1: Integrate open standard APIs to enable comprehensive transformation of the energy value chain, allowing devices from different manufacturers to integrate and share information. Where API's relate to communications with regulated system operators, mandate the system operators (on EU level , TSO and DSO) to prescribe these API's, as the competitive market will, due to competition, not be able to come forward with a standard proposal. As a 2nd step, enforce usage of these API's by EU implementing acts.

4.4.2. Not enough user centricity - tech adoption

Problem: Current energy projects often do not adequately consider the needs and involvement of end-users, limiting their effectiveness and acceptance. Not all consumers are able or interested to participate in the energy transition in the same way or to the same degree of involvement. It is therefore important that nobody is left behind in the digital transition and therefore create consumer-focused digital tools designed to meet the needs, skills, conditions, habits and expectations of different categories of market participants. The tools created should reflect the reality of demographic change with increasing numbers of older consumers who need to be specifically supported in the digital transition.

With residential areas becoming rapidly more complex as newly built areas (eg Balanswijken) and renovations will be asked to implement net neutrality, all above mentioned innovative aspects of energy communities and digitalisation will be implemented. It is not certain that people can still understand their house or their energy system. Experts won't be able to help them either if transparency is lacking on the design and agreements (contracts) underneath the system. As builders and installation companies only see their own work, oversight is lost on the outcome of the

system when it is delivered. Basically this is so new that there is still a lot to be learned. (including things going terribly wrong)

Recommendation 4.2: Establish projects that are user-centric and build transparency on the setup of different add-ons, contracts and guarantees. Take behaviour into account and learn from projects that are going wrong at the moment. (or right!). Facilitate energy communities in commencing these tasks. Start a learning environment with collaboration of all actors.

4.4.3 Enhancing Grid Transparency and Management

Problem: The current grid lacks transparency and advanced management tools, which hinders the efficient integration and optimisation of new technologies and energy systems.

Recommendation 4.3: Increase investment in living labs and pilot projects focusing on local energy systems, particularly in business areas, to gather practical insights and demonstrate the viability of new technologies and organisational models.

Recommendation 4.4: Promote the integration of edge computing to enhance real-time monitoring and grid resilience with next-generation smart meters.

4.5. Recommendations on Ecosystem Connectivity

4.5.1 Cross-Sector Collaboration and Partnerships

Problem: There is insufficient collaboration between different sectors and stakeholders, which hampers innovation and the effective deployment of energy transition solutions. There should be more involvement from underrepresented groups like citizens in energy regulation and policies. They are involved in many pilots but the lessons and best practices don't find their way to new projects or policymakers.

Recommendation 5.1: Encourage partnerships and cross-disciplinary collaborations between knowledge/research institutions and industry players to enhance innovation and deployment. Promote partnerships between public and private sectors to leverage resources and expertise for energy transition.

Recommendation 5.2: Foster stronger cooperation between IT, business managers, and legal experts across sectors, as the new system requires much higher integration and cross-sector data-sharing and cooperation. Divisions must also communicate and cooperate more. Foster stronger cross-sector cooperation, including IT, energy, and telecommunications, to enhance interoperability and innovation.

Recommendation 5.3: Increase collaboration with other countries to learn about the grid and which pilots succeeded, as the Netherlands is not unique in its problems.

Recommendation 5.4: Establish an action team for digitalisation with a quadruple helix approach, including an overview of bottlenecks.

4.6. Recommendations on Resilient Growth

4.6.1 Adapt to changes - Modular and Agile Regulatory Approaches

Problem: Regulations need to be flexible and adaptable to keep up with rapid technological advancements in the energy sector.

Recommendation 6.1: Implement modular regulatory approaches to allow for agile and incremental adjustments. For example, making 20 different modules in the energy law, focusing on different areas, like data sharing, enables much faster adjustments. Also the EU should define such a modular framework and work agile, and enforce the member states to adopt the EU framework.

Recommendation 6.2: More regulatory-free spaces e.g. Sandbox area's like the Green Village and Scheveningen to enable new technologies, new regulatory frameworks, including incentives like new tariffs and different ways of collaboration with new roles and responsibilities to be tested. Have eye for end-users with testing and focus on tech adaptation and buy in from local communities.

4.6.2 Promote citizen engagement and community-oriented energy solutions

Problem: There is insufficient citizen engagement and involvement in community-oriented energy solutions, which limits public awareness, acceptance, and buy-in for sustainable energy practices.

Recommendation 6.3: Promote citizen engagement and community-oriented energy solutions to ensure active involvement and commitment by citizens by equally sharing gains and benefits from renewables and digitalisation with consumers. This approach can drive the energy transition and ensures that people are actively involved and benefit directly from sustainable energy practices. This can be realised via an implementing act on energy sharing following the adopted EMD legislation. This implementing act should also clearly define homework for the system operators (this to accelerate in speed).

Recommendation 6.4: Ensure decision-making processes involve stakeholders who are directly impacted by energy transitions to better address real-world challenges. Integrate public values and foster social innovation.

4.6.3. Simulations for every region to anticipate future developments

Problem: The current focus on individual capacity management limits the efficiency and potential of shared energy solutions. Modelling the impacts of the planned growth of energy usage and production will give understanding for the need for cooperation and digitalisation. With modelling governments, DSO's and end-users get a clear view on the most optimum solutions available.

Recommendation 6.5: Develop scenario modelling for the government to test their actions, such as incentives, locations, balancing rules, new products, and electrification. This is crucial for regions and provinces to understand potential outcomes.

Recommendation 6.6: Promote the development and implementation of digital twins and AI technologies to optimise energy system monitoring, management, smart charging, location of production, storage and systemintegration. Focus on shifting from individual capacity management to collective solutions, promoting a hub-based approach where multiple entities share capacity.

4.6.4 Fostering Leadership and Governance

Problem: There is a lack of clear leadership and governance in the energy sector, which leads to inefficiencies and a slow adoption of innovative solutions.

Recommendation 6.7: Develop a clear leadership attitude; especially at ministry, regulatory and system operators executive level. Currently, there is uncertainty about who should take the lead. Increase direct contact with entrepreneurs with strong and innovative solutions. Connect with them, hear them, talk to them, and go to them.

5. Recommendations for the action plan for Slovakia

5.1. Status overview across action plan focus areas

Slovakia faces a number of challenges in the green, digital transition of its energy sector, with barriers for innovation across all areas of the action plan framework. Throughout the stakeholder engagement activities three key areas regularly came up as the most significant and highest priority topics that would be current blockers for the transition. These were:

- **Conservative mindset** regarding the importance of the **green transition** and the need for **digital innovation** within the energy sector - widespread at both citizen, industrial, and political level
- **Lack of strategic alignment** on how to approach the transition resulting in a lack of coherent roadmap and encouragement for industry
- **Inadequate funding** ecosystem - under-financed (particularly national funding), in-accessible (excessive bureaucracy) and mis-directed, spanning both industry (SMEs and startups) and academia (limited ability to translate academic theory into innovative market ready solutions)

The challenge of mindset and strategic alignment are entrenched within the political, social, and historical context of Slovakia and will require complex, multidisciplinary, cross-quadruple-helix actions to be overcome. Being able to identify tangible actions to facilitate this change will be essential to ensuring measurable progress in this area. Unblocking these areas will be essential for meaningful changes in the remaining action areas of Technology Adoption & Deployment; Ecosystem Connectivity; and Resilient Growth.

It is worth noting that within the Slovakian context, stakeholders frequently remarked that the Slovak ecosystem was significantly behind its European peers in the digital transition of the energy sector, and therefore whilst many of the base technologies required for the transition may not be considered innovative on a global / European scale, within the Slovakian market these can still represent significant innovations in process and market readiness / deployment.

Other major challenges within the Slovakian ecosystem include a regulatory framework burdened with significant bureaucracy and slow legislative processes, a reactive rather than proactive industry with inbuilt innovation, digitalisation and diversification blockers (electricity pricing, steady and predictable usage, and abundance of nuclear) and limited testing spaces and promotion of innovations. Additionally, public awareness and education on green technologies remain low, with a disconnect in understanding social innovation beyond poverty and disability contexts, historical distrust between society and government, and a reluctance to leverage and share data (a cornerstone of digitalisation) due to privacy concerns and market influence.

To overcome these obstacles, Slovakia needs clear and supportive legislative changes to promote renewable energy projects and reduce bureaucratic hurdles. Enhanced financial support from both government and EU funds is crucial to drive innovation and infrastructure development. National-level education campaigns are essential to raise awareness about energy efficiency and renewable opportunities, emphasising the importance of behavioural change. Promoting collaboration between universities, the private sector, and municipalities can foster innovation, particularly in energy sharing and smart technologies. Robust data management and cybersecurity measures are also key to optimising decision-making and ensuring secure data sharing.

5.2. Prioritised recommendations for the action plan

5.1. Recommendations on Policy & Regulation;

5.1.1 Improve strategic planning and coordination capacities for energy transition at national and regional level.

Slovakia's national innovation and energy strategies will be the cornerstone of a successful digital energy transition to a resilient, efficient and sustainable energy economy, with an increased share of renewable energy sources and an increased role of local, distributed energy production. To realise this, greater EU, national, and regional alignment, detailed planning, and effective stakeholder engagement is required.

Recommendation 1.1: Update key national strategy documents (e.g. NECP, RIS3 etc.) to reflect energy digitalisation opportunities / priorities and diversification of energy supply through RES.

Recommendation 1.2: Develop cross-sector, cross-departmental national-level strategic roadmap to realise the vision outlined within strategic documents. Roadmap to reflect cross-competency nature of actions required and ensure alignment between different national agendas and priorities e.g. education, climate, security etc. as opposed to each being addressed in isolation

Recommendation 1.3: Review stakeholder composition, mandate and influence of existing government-backed energy transition working groups to ensure recommendations are reflected in national strategies / policies / regulation going forward. Ensure these groups incorporate experts from across quadruple helix and not overly weighted to incumbents / status quo representatives.

Recommendation 1.4: Introduce effective alignment and feedback mechanisms for national and regional climate officers to ensure connect / alignment between ambitions (e.g. regional policies have embraced hydrogen, water, security etc. but not addressed sufficiently in national action plan)

Recommendation 1.5: Introduce regional policy advisors into strategic positions within EU alliances / national strategy unit

Stakeholders involved:

Government Ministries responsible for energy and innovation agendas

National advisory / working groups for energy transition (e.g. existing interdepartmental working groups; Climate Coordination Policy Commission working groups (Low-carbon strategy; adaptation strategy); Technical working groups etc.)

Funding and resources:

To be updated over the course of the remaining stakeholder engagement activities

Timeframe, milestones and monitoring:

Short-medium term - immediate support for strategic review and update of relevant strategies to act as foundation for the broader energy transition and guide downstream activities

5.1.2 Reduce bureaucratic regulatory barriers to efficient deployment of RES and digital solutions

Currently those stakeholders who are motivated and engaged in the energy transition are facing significant obstacles to act, with outdated, inconsistent and overly bureaucratic processes in place

for the implementation of new energy technologies and renewable energy sources. A streamlined regulatory framework will accelerate the transition and help to build momentum and buy-in with industry stakeholders, both SMEs and corporates.

Recommendation 1.6: Conduct review of existing regulatory policy across full array of renewable energy technologies and digital energy solutions

Identify and implement opportunities for standardisation and simplification of regulation

Recommendation 1.7: Conduct process review to identify major bureaucracy bottlenecks within regulatory process for installation / deployment of energy tech solutions

Recommendation 1.8: Incentivise more proactive and flexible regulatory updates to support uptake of new technologies and innovations

Recommendation 1.9: Conduct behavioural change analysis and implement good practice behavioural change incentives within relevant government departments and public offices to drive more risk-tolerant approach to R&I processes within the energy sector and beyond

Stakeholders involved:

Government Ministries responsible for energy and innovation agendas

Industry and SME innovators and green transition champions engaging with existing regulatory processes

Funding and resources: To be updated over the course of the remaining stakeholder engagement activities

Timeframe, milestones and monitoring: Short-medium term

5.2. Recommendations on Market state & Funding;

5.2.1 Improve accessibility of national funding for innovative energy transition

Currently innovators within the Slovakian ecosystem are largely reliant on European funding with national opportunities limited and unpopular due to long-standing accessibility issues tied to bureaucracy and a lack of market consultation resulting in funding being misdirected away from priority areas. It should be noted that there are good examples of national funding being made available in recent years for uptake of green technologies (e.g. Green Households Programme) by citizens and SMEs alike, more must be done to support the technology development itself.

Recommendation 2.1: Increase in funding is required across the board within the clean energy transition, with stakeholders from academia through to industry highlighting a lack of funds for the successful deployment and scaling of green energy innovations. Increased funding will allow a greater uptake of Slovakian energy solutions, and will bolster the profile and public perception of the sector and its growth & economic opportunities resulting in positive downstream impacts on workforce and international reputation.

Recommendation 2.2: Reduction in red-tape for funding access is a key measure to ensure funding that is being made available is taken up by industry and academia. Currently stakeholders report that the level of bureaucracy and reporting required for national funding specifically often results in them discounting it from their potential funding pool

Recommendation 2.3: increased market consultation at both the strategic planning and grant preparation phase to ensure opportunities match the latest market requirements

Recommendation 2.4: Increased focus on promoting cross-sector (academia-industry) collaboration via national funding

Stakeholders involved: National funding bodies & Innovation agencies; Industry, SMEs and other market innovators

Funding and resources: To be updated over the course of the remaining stakeholder engagement activities

Timeframe, milestones and monitoring: To be updated over the course of the remaining stakeholder engagement activities

5.2.2 Target under-addressed, high-impact energy sectors

Given the significant weighting of nuclear within Slovakia's energy mix, there is a common perception that the introduction of alternative renewable and clean energy sources for electricity generation within Slovakia is a low priority. Despite this, the heating and (nascent) cooling industries remain highly reliant on natural gases with national plans indicating this will only increase in the near-term with no concrete roadmap for transitioning to geothermal, wind, solar, or biomass and limited support for innovation.

Recommendation 2.5: Reduce regulatory barriers around deployment of alternative heating sources such as geothermal

Recommendation 2.6: Increase funding support for heat pumps

Recommendation 2.7: Share good practice on innovative deployment / business cases for the sector (i.e. Bratislava ice rink)

Stakeholders involved: National funding bodies & Innovation agencies; Industry, SMEs and other market innovators; Advocacy and awareness building organisations / non-profits

Funding and resources: To be updated over the course of the remaining stakeholder engagement activities

Timeframe, milestones and monitoring: To be updated over the course of the remaining stakeholder engagement activities

5.3. Human capital: Education, Awareness, Workforce;

5.3.1 Align workforce planning with the needs of the energy transition

There is a significant knowledge gap in Slovakia's workforce to facilitate the energy transition. Although there is a high level of expertise on specific energy related topics, this does not cascade through industry nor the public sector into a practical understanding of how to manage the transition. Particularly within the nation's SMEs and public authorities, there is a lack of knowledge of how to prioritise and implement the required changes which prevents the uptake of energy solutions, scaling of innovations, and progress in the transition. Education reform, alignment of strategic workforce planning with national climate agendas, and talent management reviews are required to overcome these challenges.

Recommendation 3.1: Conduct a workforce assessment to identify specific skill gaps in line with the country's specific climate goals and digital transition strategy. Update and design new curricula specifically designed to support the promotion of clean energy technologies and innovation including consideration for the role education can have in disrupting the risk averse mindset that currently dominates the workforce.

Recommendation 3.2: Adopt Industry-oriented university education models to support improved technology transfer and relevance of academic work and education to the practical needs of industry and the broader workforce, thereby improving the potential of academia within the innovation value chain.

Recommendation 3.3: Review and design talent management and retention pathways specifically for the energy sector to make these career paths more attractive for a new generation of students and incoming workforce. These should incorporate financial incentives, vision for career

development and progression, and learning opportunities via upskilling and reskilling opportunities. These pathways should be communicated and disseminated at all levels from secondary school through to experienced professionals within and outside the industry.

Stakeholders involved: industry leaders; worker associations; Advocacy groups; policy makers & public authorities with education and skills mandate; HEI; Research & think tanks

Funding and resources: To be updated over the course of the remaining stakeholder engagement activities

Timeframe, milestones and monitoring: To be updated over the course of the remaining stakeholder engagement activities

5.3.2 Enhance public interest in and awareness of the climate agenda and energy transition requirements

Without public support for the climate agenda and energy transition, industry and government structures alike will not be subject to significant market / societal driven pressures to enact the necessary changes at pace. With current transition planning being driven primarily by economic elements, strategic opportunities for greener, more sustainable practices are not being addressed and as such slow progress is being made in the transition. Shifting public perceptions around the transition and increasing awareness on the importance and opportunities (balancing financial and climate), as well as illustrating how the change can be achieved to the consumer / society's benefit will be key for building the necessary momentum in the transition.

Recommendation 3.4: Conduct behavioural analytics study to identify measures to drive change in public perception of the importance of the energy transition and climate agenda

Recommendation 3.5: National-level education campaigns to inform smaller companies and consumers about new opportunities and tools for energy efficiency and renewable energy including specific efforts to tackle disinformation around underperformance of RES technologies within mainstream media and political discourse

Recommendation 3.6: Increased awareness building of climate crisis within the education system (introduce climate / energy agenda in secondary school education onwards)

Stakeholders involved: public authorities implementing public awareness campaigns and those with influence over educational curricula; educational institutes; NGOs and nonprofits; Media & Comms platforms; Community groups; Industry

Funding and resources: To be updated over the course of the remaining stakeholder engagement activities

Timeframe, milestones and monitoring: To be updated over the course of the remaining stakeholder engagement activities

5.4. Technology Adoption & Deployment;

5.4.1. Improve dissemination of existing resources and facilities to support energy innovation

Whilst there are numerous resources and facilities available to support Slovakia's energy transition dn the development or relevant innovations, awareness of these is low, with many stakeholders lacking visibility of the support available and unaware of the deployment of successful models that they can learn from elsewhere. These include the presence of digital twins and testing ecosystems (URSO, Energy Data Center etc.), tacit knowledge from industry and public authority experts (e.g. lessons from Mesto Trnava as a frontrunner in the municipal digital energy transition) and others.

Recommendation 4.1: Create public database of energy innovation support resources and facilities (e.g. Technical incubators at university hubs, digital twins, public funding opportunities and support)

Recommendation 4.2: Create online training / learning materials leveraging success stories and highlighting under-leveraged implementation mechanisms for deployment of energy solutions (e.g. novel business cases and alternative financing schemes, energy performance contracts etc.)

Recommendation 4.3: Partner with civil society organisations to design and disseminate learning materials and maximise reach

Recommendation 4.4: Partner with private and public organisations to offer specific application support for accessing funding for green energy solutions

Stakeholders involved: Research & academic institutes with thematic expertise; NGOs and nonprofits to advocate, educate, and facilitate partnerships; community groups for sharing / proliferation of knowledge; industry associations and professional networks; tech and innovation hubs; media and comms platforms

Funding and resources: To be updated over the course of the remaining stakeholder engagement activities

Timeframe, milestones and monitoring: To be updated over the course of the remaining stakeholder engagement activities

5.4.2 Prioritise roll-out of data-gathering solutions to allow for widespread informed decision making

Although there is limited demand-side drive for energy efficiency tech due to low energy prices supported by government subsidies, the roll-out of systems and distributed devices that allow real-time data gathering, aggregation, and analysis is essential to the sophisticated portfolio-level management of Slovakia's public and private energy consumption. At present quality of data is a key blocker to this and despite legislative structures being in place to enable the roll-out, this has not been taken up at a widespread level. Public authorities and incumbents must lead by example and use data gathered to inform strategic long-term planning for the transition of all assets instead of doing so at siloed unit scale.

Recommendation 4.5: Public funding for smart energy management installations and other data measurement and collections distributed assets

Recommendation 4.6: National education campaign on cost-savings and climate benefits of energy efficiency

Stakeholders involved: Regulatory bodies; utilities / grid operators; Prosumer / civil society groups; NGOs / advocacy; Industry & SME solution providers

Funding and resources: To be updated over the course of the remaining stakeholder engagement activities

Timeframe, milestones and monitoring: To be updated over the course of the remaining stakeholder engagement activities

5.5. Recommendations on Ecosystem Connectivity;

5.5.1 Increase cross-sector and cross-disciplinary collaboration to improve outcomes of innovation process

Given the inherently multidisciplinary and international nature of the energy sector, any efforts to transform it should reflect these characteristics. A frequently raised challenge within the Slovak innovation ecosystem was the reduced role that academia currently plays primarily due to a combined shortcoming of funding and cross-disciplinary collaboration opportunities, and a lack of awareness from industry of the support and infrastructure available through institutions such as university innovation hubs.

Recommendation 5.1: Provide increased financial and process support for applicants to EU funding programmes with a focus on cross-sector / cross-disciplinary projects.

Recommendation 5.2: Increase funding for university-led innovation hubs to boost their visibility and encourage greater uptake of their services to better leverage existing knowledge and encourage transfer of knowledge from academia to industry

Recommendation 5.3: Support for strategic partnership building, particularly international partnerships where can learn from best practice

Recommendation 5.4: Establish regular knowledge sharing forums and networking events at both a local, regional, national and international level to create new collaboration opportunities

Stakeholders involved: To be updated over the course of the remaining stakeholder engagement activities

Funding and resources: To be updated over the course of the remaining stakeholder engagement activities

Timeframe, milestones and monitoring: To be updated over the course of the remaining stakeholder engagement activities

5.6. Recommendations on Resilient Growth

5.6.1 Facilitate data sharing and accessibility with regulatory ecosystems

The role of data within Slovakia's energy transition is at a very early stage, with knowledge, implementation, and cultural barriers. Attitudes towards data sharing within Slovakia are highly conservative, with significant concerns around GDPR and competitive advantage controlling the narrative. Additionally, collection of granular data regarding the energy market is challenging given there has been significant challenges in the roll-out of demand side IOT energy cloud solutions such as smart meters, with one of the lowest penetration rates in Europe, when it prevents access to key consumption data. What data is gathered is further obscured by a lack of transparency over data being held by energy market actors, and a reluctance to share this for the purpose of improved innovation and optimised decision making for stakeholders across the quadruple helix. Many of these challenges are not unique to Slovakia and there is a good opportunity to build a new set of principles and regulations in this space, as well as driving deployment of tech that will better collect and analyse data, in partnership with other EU peers.

Recommendation 6.1: Design a governance framework that encourages data sharing and availability at a granular (anonymised) level to enable optimisations of the overarching system and facilitate innovation capacities of new market entrants.

Recommendation 6.2: Promote the uptake of the energy data centre - a central platform for data exchange. It will centrally store and distribute data, facilitating the development of smart solutions, (electricity sharing, flexibility and aggregation), and participation of new market participants

Recommendation 6.3: Ensure consumers and all market participants from business owners through to public authorities are educated on the potential role data sharing can play in the transition to shift away from the current negative narratives that dominate the topic

Stakeholders involved: To be updated over the course of the remaining stakeholder engagement activities

Funding and resources: To be updated over the course of the remaining stakeholder engagement activities

Timeframe, milestones and monitoring: To be updated over the course of the remaining stakeholder engagement activities

5.6.2 Enhance narrative and understanding of cyber security challenges within the digitalisation of the energy sector

Cyber security will be an integral pillar of an increasingly digitalised energy sector that interfaces with every frontier of our daily lives, from our homes to the cars we drive. As such serious consumers, public authorities and industry leaders alike will need increased awareness of how to navigate this space, and innovators and energy providers and distributed energy asset suppliers will need to incorporate this into all aspects of their value chain design and development.

Further engagement with stakeholders involved in the area of cyber security will be required in the upcoming months to elaborate on specific recommendations in this space.

Stakeholders involved: To be updated over the course of the remaining stakeholder engagement activities

Funding and resources: To be updated over the course of the remaining stakeholder engagement activities

Timeframe, milestones and monitoring: To be updated over the course of the remaining stakeholder engagement activities

6. Recommendations for the action plan for Ukraine

6.1. Status overview across action plan focus areas

The Ukrainian energy innovation ecosystem faces a number of challenges, which anticipate changes across all ecosystem dimensions: infrastructure, business models, stakeholders' collaboration etc. On one hand, Ukraine faces challenges with a monopolised energy sector plagued by corruption, slow innovation, inadequate funding and the deliberate destruction of energy infrastructure. Destroyed energy infrastructure, nuclear and renewable generation and low storage capabilities leads to a severe **grid congestion** issue. The situation requires quick actions to get the system back to work and support the daily operations of consumers - businesses and households. Thus implies using solutions, which are already available and not necessarily innovative. These quick actions might also compromise green and digital transition to cheap and immediate solutions. On the other hand, the **old models are demolished**. On a transition X-curve, Ukraine skipped to the chaos point at once due to the war, and badly needs new solutions for all aspects of the energy ecosystem. This is a favourable time to rebuild the whole system following new principles of green, digital and fair transition while taking into account Ukrainian integration into EU research and innovation ecosystem and the energy market. An opportunity stems from the fact that the ongoing military aggression has made energy security and independence the top priority. Achieving this requires decentralisation and digitalisation, aligned with EU ambitions. Ukraine is **able to create innovative solutions.** Given that Ukraine has a strong academic and entrepreneurial potential, digitalisation is considered a priority on a nationwide level which combined together and supported by the right instruments could create the right solutions. It is crucial to raise awareness among citizens and professionals about these goals.

Stakeholder dialogue within the WEnnovate project allowed us to identify priority challenges, named by representatives of different stakeholder groups, which are to be addressed in the first place:

- **Priorities' misalignment** on the strategic and tactical level as well as on regional and national levels. Harmonisation is needed with the EU and clear rules and regulations.
- **Monopolised and corrupted** market that favours projects with **quick returns and fast implementation. Nondiscriminatory** public funding **programs and other financial**

instruments are expected from the ecosystem for private and public actors.

- **Lack of employees** in a male-dominated sector.
- **Weak innovation ecosystem.** Many new projects were put on hold due to the war **though** geography still allows **sun and wind energy generation** to be increased in Ukraine. **Energy efficiency solutions** have been recently adopted across all sectors - industry, local communities, households, however the country **lacks scaling examples** of regions achieving energy efficiency.
- **Lack of collaboration and synergies despite** strong academic sector, open for collaboration.
- **Limited access to data** prevents **decentralised energy generation.**

Unfortunately, the ongoing military aggression demands all public attention, sidelining energy transition unless it aligns with energy security. However, energy sector decentralisation, digitalisation and renewable production can gain significant attention if aligned with reconstruction efforts. Amid high costs of new technologies, Ukraine should focus on scaling successful projects that achieve energy efficiency, decentralisation, and resilience.

6.2. Prioritised recommendations for the action plan

6.1. Recommendations on Policy & Regulation

6.1.1. Recommendations to improve strategic planning and coordination capacities for energy transition at national and regional level.

Recommendation 1.1: Establish requirements for innovation

Recommendation 1.2: Create a national vision for energy sector transformation

Recommendation 1.3: Align green and digital transitions with deep tech as a strategic approach at all policy levels

Recommendation 1.4: Restructure ministries to focus on both energy and climate

Recommendation 1.5: Implement changes in line with the EU Fit for 55 initiative

Recommendation 1.6: Ensure Ukrainian companies comply domestically with EU standards

Recommendation 1.7: Align national regulations with EU integration requirements

Stakeholders involved: Government Ministries responsible for energy and innovation agendas; National working groups

Funding and resources: To be updated over the course of the remaining stakeholder engagement activities

Timeframe, milestones and monitoring: Short-medium term - immediate support for strategic review and update of relevant strategies to act as foundation for the broader energy transition and guide downstream activities

6.1.2 Recommendations to improve economic policies.

Recommendation 1.8: Establish clear and stable economic policies

Recommendation 1.9: Reform household subsidies to assist only those in need

Recommendation 1.10: Support entrepreneurship in the energy sector

Recommendation 1.11: Identify and scale local success stories and projects

Recommendation 1.12: Promote inclusion of underrepresented groups in energy and technology sectors

Recommendation 1.13: Focus on developing energy-efficient solutions based on renewable energy as part of the Smart Specialisation Strategy

Stakeholders involved: Government Ministries responsible for energy and innovation agendas; National working groups; Facilitators; Local governments; Local energy communities; SMEs

Funding and resources: To be updated over the course of the remaining stakeholder engagement activities

Timeframe, milestones and monitoring: Short-medium term - immediate support for policy reviews, broader stakeholder dialogue and communication of success stories.

6.1.3 Recommendations to align energy priorities with reconstruction efforts.

Recommendation 1.14: Establish a shared objective for reconstruction

Recommendation 1.15: Utilise the opportunity that destroyed generation facilities can be replaced with decentralised, digitised energy systems

Recommendation 1.16: Enhance energy decentralisation to increase resilience against blackout risks

Recommendation 1.17: Develop local lithium mining and battery production companies

Recommendation 1.18: Launch a national communication, awareness, and education campaign on renewable energy supported, decentralisation and digitalisation by the government

Stakeholders involved: All

Funding and resources: To be updated over the course of the remaining stakeholder engagement activities

Timeframe, milestones and monitoring: Short-medium term - implement energy decentralisation requirements into the reconstruction/rebuilding projects while creating favourable economic and regulatory conditions for local production companies

6.2. Market state & Funding;

6.2.1 Recommendations to improve investment and funding opportunities.

Recommendation 2.1: The government should create conditions for profitable private investment instead of trying to maintain artificially low tariffs

Recommendation 2.2: Attract more EU public funding for reconstruction, by aligning energy security goals with digitalisation, decentralisation and clean generation

Recommendation 2.3: Make grant programs for research and innovation available for private research organisations and business (avoid favouritism towards state research establishments)

Recommendation 2.4: Establish an independent judiciary to secured investments to ensure the right placement of investment and reduce corruption

Stakeholders involved: Government Ministries responsible for energy and innovation agendas; National Academy of Sciences; Ukrainian Startup Fund

Funding and resources: To be updated over the course of the remaining stakeholder engagement activities

Timeframe, milestones and monitoring: Short-medium term - review of the national public funding priorities, request for EU funding of the energy-related projects, medium-term improvement of the investment climate

6.3. Human capital: Education, Awareness, Workforce;

6.3.1 Recommendations to raise awareness that digitalisation and decentralisation aligns with energy security

Recommendation 3.1: Increase number of educational/awareness programs focusing on society

Recommendation 3.2: Connect digitalisation and decentralisation with energy security

Recommendation 3.3: Local energy generation should be identified and connected to energy security and reconstruction efforts in the public's opinion

Stakeholders involved: Ministries and local governments; Facilitators; Education institutions

Funding and resources: To be updated over the course of the remaining stakeholder engagement activities

Timeframe, milestones and monitoring: Short term

6.3.2 Recommendations to train, re-skill and upskill talents for the energy sector

Recommendation 3.4: Training personnel for future projects, launching energy-related educational programs at universities

Recommendation 3.5: Creation of a training system

Recommendation 3.6: Creation of a high-quality innovative infrastructure for smart specialisation

Recommendation 3.7: Creation of tailored industry training programs, shared professionals' centers (competence centers)

Stakeholders involved: Ministry of Education; Education institutions; Research infrastructure operators

Funding and resources: To be updated over the course of the remaining stakeholder engagement activities

Timeframe, milestones and monitoring: medium- term

6.4. Technology Adoption & Deployment;

6.4.1 Recommendations to diversify power generation sources

Recommendation 4.1: Build small modular nuclear reactors.

Recommendation 4.2: Construct 100 smaller 10 MW plants instead of a single 1,000 MW power plant.

Recommendation 4.3: Invest in gas-fired flexible generation to reduce carbon emissions compared to coal.

Recommendation 4.4: Transition to gas-powered (including biogas) generation to cut greenhouse gas emissions by at least half while maintaining grid stability.

Recommendation 4.5: Build wind and solar-power stations

Recommendation 4.6: Dispel negative stereotypes about hydrogen production (e.g., 3 GW hydrogen production requires only 0.0036% of annual water usage in the Odessa region)

Recommendation 4.7: Increase participation in EU projects to offset the price difference between green and gray hydrogen

Stakeholders involved: All

Funding and resources: To be updated over the course of the remaining stakeholder engagement activities

Timeframe, milestones and monitoring: Medium-long term

6.5. Ecosystem Connectivity;

6.5.1 Recommendations to foster successful collaboration across ecosystem actors

Recommendation 5.1: Foster successful cooperation between Energoatom and academia in the nuclear sector

Recommendation 5.2: Collaborate with territorial communities for green technology implementation

Recommendation 5.3: Encourage local energy partnerships and shared energy use

Recommendation 5.4: Use the role model of the National Academy of Sciences of Ukraine that has a very horizontal structure and great communication within academia

Recommendation 5.5: Create a working sandbox method for energy companies to share their experience

Recommendation 5.6: Foster collaboration within the quadruple helix, setting up different fields labs focusing on sustainable innovation, energy independence

Stakeholders involved: All

Funding and resources: To be updated over the course of the remaining stakeholder engagement activities

Timeframe, milestones and monitoring: Short-medium term

6.6. Resilient Growth

6.6.1 Recommendations to foster secure energy data sharing

Recommendation 6.1: Establishing one shared platform for data sharing and communication among ecosystem actors

Recommendation 6.2: Ensure these platforms are equipped with robust privacy protections and user access controls to maintain data integrity and confidentiality

Recommendation 6.3: Promote a culture of transparency that encourages and incentivises players to share their data, to increase energy security and reduce costs

Recommendation 6.4: Implement advanced cybersecurity measures tailored to protect the digital infrastructure of energy systems

Recommendation 6.5: Develop secure data sharing frameworks to facilitate patent analysis while protecting sensitive information

Recommendation 6.6: Encourage partnerships between public and private sectors to enhance data availability for research and innovation

Stakeholders involved: All

Funding and resources: To be updated over the course of the remaining stakeholder engagement activities

Timeframe, milestones and monitoring: To be updated over the course of the remaining stakeholder engagement activities

7. Recommendations for the action plan for Hungary

7.1. Status overview across action plan focus areas

Hungary is facing significant challenges in the green and digital transition of its energy sector, with obstacles to innovation present across the action plan framework. Overcoming these barriers is essential for Hungary to meet its energy transition goals and foster sustainable economic growth. This set of recommendations targets key areas where the transition is hindered or where progress can be accelerated.

A major issue is the lack of strategic planning and coordination, as Hungary lacks a comprehensive strategic roadmap and suffers from poor coordination among government, industry, and academia. This has resulted in disjointed efforts and inefficient regulatory processes. The current rigid institutional framework, coupled with strict and complex regulations, further stifles innovation. The absence of regulatory sandboxes and field labs adds to these challenges. To better support innovation, Hungary needs a more flexible regulatory framework that can adapt to new technologies, support dynamic pricing, and allow for the testing of innovative energy solutions.

Public awareness of the EU action plan on the digitalization of the energy sector is low, highlighting the need for targeted capacity-building activities among relevant stakeholders. These efforts are crucial to better align agendas and fully understand the plan's scope.

While Hungary has access to a wide array of technologies suitable for digitalizing the energy sector, the challenge lies in selecting the most appropriate and cost-effective combinations and roll out implementation on a larger scale. The better and more targeted involvement of stakeholders along with funding opportunities would be beneficial for facilitating the digital transformation, enhancing efficiency, and supporting sustainable energy practices.

Addressing the challenges of strategic planning, regulatory complexity, and inadequate support will require multidisciplinary, cross-sector collaboration. This is critical for making meaningful progress in technology adoption, ecosystem connectivity, and resilient growth. Hungary must enhance collaboration among all stakeholders and adopt a unified approach to foster innovation, modernize infrastructure, and support sustainable economic growth.

7.2. Prioritised recommendations for the action plan

7.1. Policy & Regulation;

7.1.1 Recommendations to improve strategic planning and coordination capacities for energy transition at national.

In order to bring disjointed effort under one umbrella and create a framework to better adopt EU energy digitalization strategies including increased role of locally produced and distributed energy.

Recommendation 1.1: Review stakeholder composition, mandate and influence of existing government-backed energy transition working groups to ensure recommendations are reflected in national strategies / policies / regulation going forward. Ensure these groups incorporate experts from across quadruple helix and not overly weighted to incumbents / status quo representatives

Recommendation 1.2: Develop cross-sectoral working groups representing emerging market actors for creating strategic objectives e.g. ensure aggregators and energy communities are adequately represented in regulatory boards and decision-making processes.

Recommendation 1.3: Create a strategic document targeting digitalisation of the energy sector that unites vision and efforts and incorporates the measures listed in other strategic documents in case if it necessary updates them (e.g. RIS3, NECP, National Energy Strategy, RSSP + REpower EU).

Stakeholders involved:

Government Ministries responsible for energy and innovation agendas; Working groups for energy transition

Funding and resources:

To be updated over the course of the remaining stakeholder engagement activities

Timeframe, milestones and monitoring:

To be updated over the course of the remaining stakeholder engagement activities

7.1.2 Recommendations to improve regulatory framework

To advance Hungary's energy transition and digital transformation, several key regulatory measures are essential. These include reforming the tariff system to support green technologies, simplifying processes for energy communities, advocating for a flexible regulatory framework, and establishing effective regulatory sandboxes. Additionally, policies on energy sharing and the flexibility market are crucial for promoting efficient energy use and fostering innovation.

Recommendation 1.4: Adjust the tariff system to favour energy storage and other green technologies by reducing fixed connection fees for medium voltage and additional variable tariffs. Simplify permitting processes to reduce delays and uncertainty for investors.

Recommendation 1.5: Include energy communities among licensing exceptions, clarify rules for energy sharing and system usage fees, streamline administrative processes, and simplify licensing for small-scale energy communities.

Recommendation 1.6: Advocate for a flexible regulatory framework: Implement less bureaucratic regulations that adapt to new technologies, support dynamic pricing to align consumption with production, and create financial incentives for companies to invest in green technologies.

Recommendation 1.7: Implement better functioning regulatory sandbox to test innovative energy solutions and provide temporary exemptions for new projects to build viable business models. HEPURA should be able to grant temporary exemptions to test novel solutions, addressing the need for comprehensive tariff system reform due to reduced distributed electricity quantities.

Stakeholders involved:

HEPURA and Ministry of Energy; Major energy industry actors; Energy communities, flexibility providers and project owners hindered by current business models and regulatory boundaries

Funding and resources:

To be updated over the course of the remaining stakeholder engagement activities

Timeframe, milestones and monitoring: Short term

7.1.3 Increase support and funding for local governmental level

Local governments in Hungary face significant pressure to manage their large energy consumption efficiently, yet they often lack the necessary assistance and funding to independently implement digital energy sector solutions. Many municipalities are eager to engage in projects and facilitate positive change, but selecting the most appropriate and cost-efficient technology combinations and secure funds for it remains a challenge. By increasing support and funding at the local level can develop viable adaptation strategies, business models, and incentives. Involving local governments in the implementation phase will provide practical experience, enhance efficiency, and promote sustainable energy practices. This approach will create an environment where municipalities can effectively contribute to and benefit from the energy transition, accelerating Hungary's progress towards a modern, resilient, and sustainable energy systems.

Recommendation 1.8: Evaluate current energy use and identify areas for improvement.

Recommendation 1.9: Create a strategic plan with clear steps, resources, and timelines.

Recommendation 1.10: Advocate to set up funding programs with grants, subsidies, and low-interest loans or facilitate access to EU and international funds.

Recommendation 1.11: Assisting project preparatory assistance, funding and development for associations and local governments ensures broad participation, fostering practical solutions in energy transition and digitalization

Recommendation 1.12: Provide training for municipal staff on energy management and digital solutions related project preparation.

Recommendation 1.13: Adjust the program based on feedback and results.

Stakeholders involved: Ministry of Energy; Local governments

Funding and resources: To be updated over the course of the remaining stakeholder engagement activities

Timeframe, milestones and monitoring: Mid-term

7.2. Market state & Funding;

7.2.1 Recommendations for financial incentives:

Financial incentives play a crucial role in driving the adoption of sustainable energy practices and technologies. They lower the financial barriers for individuals and organisations, making it feasible to invest in energy efficiency measures, renewable energy sources, and innovative technologies. By reducing upfront costs, these incentives accelerate the transition to a greener economy, stimulate technological advancements, and foster economic growth. Additionally, financial incentives encourage the development of local energy solutions, enhance energy security, and contribute to meeting national and international climate goals.

Recommendation 2.1: Implement financial incentives for energy efficiency investments.

Recommendation 2.2: Promote the electrification of heating systems through subsidies.

Recommendation 2.3: Provide financial incentives and technical support for energy communities.

Recommendation 2.4: Provide interest-free loans and enhance access to financial resources

Stakeholders involved: Government Ministries responsible for energy, innovation and funding; Energy communities, aggregators, energy innovators, corporates investing in energy transition projects

Funding and resources: To be updated over the course of the remaining stakeholder engagement activities

Timeframe, milestones and monitoring: Mid-term

7.2.2 Recommendations for Targeted Innovation Funding and Effective Use of R&D Funds

Targeted innovation and RDI funds are crucial for energy digitalization and innovation. Stable funding structures, increased university budgets, and effective R&D investments drive technological advancements. Based on our research, most of the energy digitalization related projects we identified are financed by very competitive funding sources that require labour intensive application processes which hinders the interest.

Recommendation 2.5: Create stable funding structures to motivate corporate participation in research and innovation.

Recommendation 2.6: Increase university budgets for energy transition research.

Recommendation 2.7: Ensure R&D funds achieve tangible technological advancements.

Recommendation 2.8: Assist project funding, development, and preparation for associations and local governments.

Stakeholders involved:

To be updated over the course of the remaining stakeholder engagement activities

Funding and resources:

To be updated over the course of the remaining stakeholder engagement activities

Timeframe, milestones and monitoring:

To be updated over the course of the remaining stakeholder engagement activities

7.3. Human capital: Education, Awareness, Workforce;

7.3.1 Recommendations for Capacity building

Capacity building among stakeholders is essential for enhancing the understanding of the power and role of deep tech and digital solutions in the energy transition. There is a significant gap in technological understanding and knowledge dissemination among stakeholders in Hungary's energy sector. This is compounded by a shortage of skilled professionals trained in the latest energy technologies, which limits innovation and implementation. To address these challenges, a comprehensive capacity-building initiative is essential.

Recommendation 3.1: Increase awareness and participation from the public and key stakeholders through transparent communication, demonstrating the benefits of renewable energy technologies and addressing misconceptions

Recommendation 3.2: Training programs for the next generation of skilled professionals to manage and implement advanced energy technologies.

Recommendation 3.3: Development of specialised postgraduate courses and certifications in energy technology, renewable energy management, and smart systems to equip the workforce with the necessary skills.

Recommendation 3.4: Establishment of thematic working group cross sectoral including representative of regulators (like it was operating with the energy communities and flexibility providers)

Stakeholders involved:

quadruple helix; To be updated over the course of the remaining stakeholder engagement activities

Funding and resources: To be updated over the course of the remaining stakeholder engagement activities

Timeframe, milestones and monitoring: To be updated over the course of the remaining stakeholder engagement activities

7.3.2 Increase public awareness

Launch campaigns to educate the public about energy efficiency, renewable energy, and the importance of flexibility in energy consumption. Public awareness and societal involvement are crucial for the successful implementation of energy transition strategies. However, there is a general lack of understanding and engagement in energy transition issues, especially in rural areas.

Recommendation 3.5: Raise awareness about energy efficiency, renewable energy, and digitalisation through educational campaigns

Recommendation 3.6: Launch campaigns to build social consensus on the importance of energy transition and climate change

Recommendation 3.7: Promote not only PV renewable energy but other means like heat pump technology for both new and retrofit applications, including high-temperature heat pumps for existing radiator-based heating systems common in Hungarian homes

Recommendation 3.8: Establishment of thematic working group cross sectoral including representative of regulators (like it was operating with the energy communities and flexibility providers)

Stakeholders involved: NGOs; Electricity providers; Media

Funding and resources: To be updated over the course of the remaining stakeholder engagement activities

Timeframe, milestones and monitoring: Short-term

7.4. Technology Adoption & Deployment;

7.4.1 Recommendations to develop support and assistence to encourage companies to adopt energy management and optimization software solutions

Develop and deploy publicly funded software solutions for optimizing energy production and consumption, making them easily accessible to a broader range of actors, including small and medium-sized enterprises (SMEs). Currently, many companies, especially smaller ones, are reluctant to invest in costly energy optimization software due to market uncertainties and financial constraints. By providing publicly funded, customizable software solutions, the government can lower the entry barriers, enabling more businesses to optimize their energy use. This approach would democratize access to advanced energy management tools, fostering greater participation in energy efficiency initiatives and contributing to broader energy transition goals.

Recommendation 4.1: Facilitate collaboration with public institutions, universities, and technology partners to develop user-friendly, scalable software solutions tailored for energy optimization.

Recommendation 4.2: Ensure the software is flexible and adaptable to various energy production and consumption scenarios.

Recommendation 4.3: Implement pilot programs in select SMEs and other interested parties to test the software's effectiveness and usability.

Recommendation 4.4: Launch the software platform publicly, making it freely available or at a subsidized cost to SMEs and other interested users.

Stakeholders involved: Public funding authority; Software developing companies; Companies (especially SME's) with a need of optimizing RES and energy usage

Funding and resources: To be updated over the course of the remaining stakeholder engagement activities

Timeframe, milestones and monitoring: Short-term

7.4.2 Recommendations to implement user friendly pilot solutions for energy management and trading

Numerous studies suggest that e.g. blockchain technology can facilitate decentralised energy markets, enabling direct peer-to-peer markets and the viable integration of small-scale generation and consumption units. It enhances transparency, consumer trust, and new business models for suppliers, provided regulatory and technological obstacles are overcome. Additionally, AI and ML improve energy security, demand accuracy, and smart grid implementation. Launch a pilot program to support energy sharing, and empower energy communities. Drawing from successful implementations like Blorin, address Hungarian specificities and regulatory challenges for broader implementation and innovation in the energy sector.

Recommendation 4.5: Project preparation (project planning, stakeholder partnership building, pilot location)

Recommendation 4.6: Create a blockchain platform tailored for energy transactions, ensuring it is user-friendly (energy tracking, peer-to-peer trading, and real-time data sharing).

Recommendation 4.7: Pilot program in selected locations, starting with small-scale deployments to test the system's functionality and reliability (staff training etc)

Recommendation 4.8: Scale up by showcase as a good example, make the software solution available

Stakeholders involved:

Blockchain Coalition - Energy Working Group, Ministry of Energy, Hungarian Energy and Public Utility Regulatory Authority (HEPURA), DSO, Private software developer and/or consulting firm

Funding and resources: EU or national funding

Timeframe, milestones and monitoring: To be updated over the course of the remaining stakeholder engagement activities

7.5. Ecosystem Connectivity;

7.5.1 Recommendations to encourage the development of university-industry cooperation innovation hubs

The Green Village, a field lab for sustainable innovation on the TU Delft Campus, exemplifies the potential of university-industry collaboration. This lab provides a real-world testing ground with inhabited houses, office buildings, streets, and networks for hydrogen, DC voltage, and heat. It focuses on sustainable building, future energy systems, and climate-adaptive cities. By creating similar labs in Hungary, researchers and startups can experiment, validate, and demonstrate sustainable innovations. These labs will bridge the gap between research and practical application, fostering innovation, enhancing technology transfer, and driving progress in energy transition and sustainability.

Stakeholders involved: Universities, Energy companies

Funding and resources: EU or national funding

Timeframe, milestones and monitoring: To be updated over the course of the remaining stakeholder engagement activities

7.6. Resilient Growth

7.6.1 Recommendations for Standardization of hardware requirements and data protocols

Frontrunners in the energy transition are already facing problems due to a lack of interoperability and standardised protocols. These issues stem from the absence of standardised communication protocols, which prevent devices from working together across different manufacturers. Additionally, the lack of open standards and secure elements in energy devices limits interoperability and security throughout the energy value chain.

Given Hungary's delay in implementing such technologies, this presents an opportunity to jump ahead into advanced, interoperable energy solutions. FEAK the government established future energy data centre is working on the development of standards related to technical and communication requirements of smart meter devices, which will provide a functioning base for central data collection. This effort is great and needs to be extended to develop standards covering further devices too. Furthermore, increasing digitalisation makes energy systems more

susceptible to cybersecurity risks, therefore this aspect also needs to be addressed by learning from other EU member states who have already experience in this domain.

Recommendation 6.1: Extend standards and data protocols to further devices.

Recommendation 6.2: Integrate open standard APIs to enable comprehensive transformation of the energy value chain, allowing devices from different manufacturers to integrate and share information.

Recommendation 6.3: Encourage data sharing to optimise energy management and support renewable energy integration, create public maps and resources for grid capacities

Recommendation 6.4: Development of cybersecurity principles and definition of data aggregation levels where data sharing is possible and safe between different entities.

Stakeholders involved:

Ministry of Energy, HEPURA, FEAK; DSOs

Funding and resources:

To be updated over the course of the remaining stakeholder engagement activities

Timeframe, milestones and monitoring: Mid-term


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