European Commission

SET PLAN TASK FORCE RECOMMENDATIONS

Task Force 3: Digitalisation

Cross-cutting recommendations to advance the digitalisation of the EU energy system

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ABBREVIATIONS

Abbreviation	Definition
ACER	Agency for the Cooperation of Energy Regulators
AI	Artificial Intelligence
API	Application Programming Interface
BRIDGE	Building a Research and Innovation Data Governance Ecosystem
CDM	Common Data Model
CEEDS	Common European Energy Data Space
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CETP	Clean Energy Transition Partnership
CIIP	Common Implementation and Investment Plan
CIM	Common Information Model
COSEM	Companion Specification for Energy Metering
DG	Directorate-General
DLMS	Device Language Message Specification
DSO	Distribution System Operator
EERA	European Energy Research Alliance
ENISA	European Union Agency for Cybersecurity
ENTSO-E	European Network of Transmission System Operators for Electricity
ERA	European Research Area
ETIP	European Technology and Innovation Platform
ETIP BAT	Batteries
ETIP BIO	Bioenergy
ETIP GEO	Geothermal
ETIP HYDRO	Hydropower
ETIP OCEAN	Ocean Energy
ETIP PV	Solar Photovoltaics
ETIP RHC	Renewable Heating and Cooling
ETIP SNET	Smart Networks for Energy Transition
ETIP SNETP	Sustainable Nuclear Energy Technology Platform
ETIP WIND	Wind energy
ETSI	European Telecommunications Standards Institute
EV	Electric Vehicle
GAIA-X	European data infrastructure initiative
GDPR	General Data Protection Regulation
IEC	International Electrotechnical Commission

Abbreviation	Definition
IoT	Internet of Things
IWG	Implementation Working Group
IWG CCS-U	Carbon Capture, Storage, and Utilisation
IWG DCT	Direct Current Technologies
IWG EEB	Energy and Resource Efficiency in Buildings
IWG GEO	Geothermal Energy
IWG H2	Hydrogen
IWG ES	Energy Systems
IWG IND	Sustainable and Efficient Energy Use in Industry
IWG NS	Nuclear safety
IWG OCEAN	Ocean energy
IWG PEDs	Positive Energy Districts
IWG PV	Solar Photovoltaics
IWG RFB	Renewable fuels and bioenergy
IWG CST	Concentrated Solar Thermal
IWG WIND	Wind energy
KPI	Key Performance Indicator
ML	Machine Learning
NIS2	Network and Information Security Directive 2
NZIA	Net-Zero Industry Act
OT	Operational Technology
R&I	Research and Innovation
SCADA	Supervisory Control and Data Acquisition
SET	Strategic Energy Technologies
SGAM	Smart Grid Architecture Model
SRIA	Strategic Research and Innovation Agenda
TSO	Transmission System Operator
V2G	Vehicle-to-Grid

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EXECUTIVE SUMMARY

The recommendations of the Task Force on 'Digitalisation' aim to support the integration of digital technologies and seamless digital data flows across the energy sector. Digitalisation underpins the transformation of the European energy system, enabling secure data exchange, interoperability and cross-sectoral integration essential to accelerate the clean energy transition.

The Task Force on 'Digitalisation' developed **eight recommendations**. The recommendations address common data infrastructures, data sharing incentives, smart meter interoperability, common data structures, European data hubs, data prioritisation, the European energy data space rollout, and cyber resilience. The recommendations were created by the Task Force members, independent experts, the Task Force Leader and Facilitator. The European Commission Policy Officers had an observer role in the development process.

The recommendations specify **why** action is needed, **what** solutions could address the identified challenges, and **how** they could be implemented. The full recommendations also indicate **who** the target audience is of the recommendation, **when** the recommendation should be implemented, and the **KPIs** that could be used to track progress.

The Task Force recommendations target key SET Plan stakeholders: primarily the Implementation Working Groups (**IWGs**) and the European Technology and Innovation Platforms (**ETIPs**), but also the European Energy Research Alliance (**EERA**) and the Clean Energy Transition Partnership (**CETP**). The recommendations can also be relevant to funding agencies of Member States. The Task Force members, representing the IWGs, ETIPs, EERA and CETP, have expressed strong interest in implementing the recommendations. Implementation is encouraged to commence in 2026 and continue throughout 2027-2030. Progress can be monitored using the proposed KPIs.

Recommendation 1: Create common data infrastructures where data is accessible, leading to federated energy data spaces

Why: Energy data across Europe remains fragmented, largely inaccessible, and insufficiently exploited due to unclear data ownership, high digitalisation costs, confidentiality concerns, and cybersecurity risks.

What: This recommendation supports R&I activities contributing to the creation of common data infrastructures, enabling the gradual emergence of federated energy data spaces.

How: IWGs, ETIPs, EERA, and CETP are recommended to identify priority data needs, use cases and datasets, while also considering the recommendations from the Smart Energy Expert Group and the framework defined by the Common European Energy Data Space. SET Plan groups should promote collaborative research, pilots, and demonstration projects exploring secure and trusted data exchange across the energy value chain, including cross-sectoral integration with transport, agriculture, and buildings. These activities should support the development of data marketplaces, Artificial Intelligence (AI) tools, advanced analytics and digital twins, contributing to increased renewable energy integration and enhanced cross-sectoral energy system integration.

Recommendation 2: Develop data sharing incentives for data holders

Why: Despite rapidly growing volumes of energy data, much remains unshared due to confidentiality concerns, strategic positioning, underestimation of data value and a lack of digital skills.

What: This recommendation supports R&I actions aimed at identifying and testing data sharing incentives for data holders, enabling the development of data valorisation mechanisms within the energy sector.

How: IWGs, ETIPs, EERA, and CETP are recommended to explore approaches that demonstrate the value of shared energy data through collaborative projects, pilots, and knowledge exchange initiatives. This should include exploiting the portfolio of incentive mechanisms for data sharing and increasing awareness of the Data Act. They should also support the use and development of AI tools, digital twin applications, data marketplaces, and cross-sectoral data spaces. These activities should support the development of digital services that accelerate renewable energy integration, enable consumer participation, and improve the energy performance of buildings and distribution grids.

Recommendation 3: Create common interoperability standards for smart meters, leading to Pan-EU smart metering standards initiatives

Why: Europe's smart metering landscape remains deeply fragmented, with inconsistent adoption of standards, proprietary protocols and varying functionalities across Member States, limiting consumer empowerment and cross-border energy services.

What: This recommendation supports R&I activities that exploit common interoperable approaches for smart metering systems across Europe.

How: IWGs, ETIPs, EERA, and CETP are recommended to support activities that demonstrate how interoperable smart metering enables real-time access to energy information, facilitates demand response and flexibility markets, and supports the development of consumer-centric digital energy services. Through coordinated R&I actions, SET Plan groups can also explore how smart meter data can support renewable energy integration, reduce peak demand and improve efficiency across the European energy system.

Recommendation 4: Promote common data structures and standardisation in the energy sector, leading to common data models in energy

Why: The continued use of proprietary data formats and stand-alone data models across the European energy industry prevents end-to-end integration, raises costs, and blocks key applications such as grid integration of electric vehicles, digital twin deployment and real-time demand response.

What: This recommendation supports R&I activities that promote the use of common data structures within the energy sector, including shared energy data models to ensure semantic interoperability across electricity, heating, cooling, water, gas and e-mobility.

How: IWGs, ETIPs, EERA, and CETP are recommended to test interoperable data architectures through collaborative projects and cross-sector pilots. Herein they could rely on unified Application Programming Interfaces (APIs) to enable secure, standardised data exchange between platforms and stakeholders. Such efforts will improve data usability for digital energy applications and enable innovative services such as e-mobility solutions, smart building services, flexibility services and digital energy management tools. They can also facilitate system-wide initiatives involving the development of digital twins of energy networks and decentralised optimisation tools.

Recommendation 5: Expand European data hubs to host energy-related datasets

Why: Energy data across Europe remains siloed within national systems, hampered by poor interoperability, cybersecurity risks, data quality issues and dependence on non-European cloud infrastructure, undermining data sovereignty and cross-border cooperation.

What: This recommendation supports initiatives aimed at expanding European data hubs to host energy-related datasets. This includes the adoption of a Hub-of-Hubs architecture with standardised APIs to interconnect national and sectoral data hubs through a common framework. This approach should align with and contribute to the development of European energy data spaces, enabling the structured, interoperable integration of energy data at the EU level.

How: IWGs, ETIPs, EERA, and CETP are recommended to set up R&I activities and pilot projects that can help identify relevant datasets and demonstrate how interconnected data platforms improve data accessibility and usability. They can also promote collaboration and knowledge sharing to support greater renewable energy integration, the development of positive energy districts and advanced energy system management.

Recommendation 6: Develop a data prioritisation framework for the SET Plan

Why: The rapid proliferation of Internet of Things (IoT) networks and smart devices generates massive volumes of energy data, yet much remains unshared or indiscriminately shared, risking communication network overload while leaving high-value datasets underutilised for innovation and system optimisation.

What: This recommendation supports the development of a data prioritisation framework to identify and prioritise key datasets for sharing within the SET Plan ecosystem. This should include methodologies for classifying and ranking data by relevance and impact, ensuring that data-sharing efforts focus on high-value datasets relevant to renewable integration and energy system optimisation.

How: IWGs, ETIPs, EERA, and CETP are recommended to set up R&I activities and stakeholder engagement that promotes the use of AI-driven dynamic prioritisation approaches and define domain-specific use cases where relevant datasets are identified, analysed and prioritised. This will promote efficient and impactful data-sharing practices and help avoid unnecessary data flows that could overload communication networks or data storage systems.

Recommendation 7: Develop a European energy data space rollout plan

Why: The effective digitalisation of the energy sector faces critical challenges including fragmented and inconsistent data across systems, significant implementation costs, gaps in regulatory and market frameworks, and insufficient trust and incentives for data sharing among stakeholders.

What: This recommendation promotes activities supporting the development of a phased rollout plan for the European Energy Data Space, considering also the recommendations from the Smart Energy Expert Group and the framework defined by the Common European Energy Data Space.

How: IWGs, ETIPs, EERA, and CETP are recommended to foster projects focusing on high-impact cross-sectoral and cross-border use cases, such as coordination between Transmission and Distribution System Operators, e-mobility and demand response. Through R&I projects, demonstration activities, and stakeholder collaboration, these initiatives can test data-sharing mechanisms and digital solutions across energy sectors and Member States, promoting the design, testing, and validation of advanced AI-based, data-driven services and digital twin applications to optimise energy system planning and operation.

Recommendation 8: Develop a cyber resilience action plan

Why: The rapid digitalisation of the energy system creates significant new cybersecurity risks, with the proliferation of interconnected IoT devices, distributed energy resources and complex data platforms exposing the sector to an expanded threat landscape. Gaps in EU-wide standards and the inadequacy of traditional perimeter-based security models compound this challenge.

What: This recommendation promotes R&I activities contributing to a cyber-resilient architecture for digitalised energy systems, ensuring that future energy infrastructures are secure-by-design.

How: IWGs, ETIPs, EERA, and CETP are recommended to promote projects implementing a holistic defence-in-depth approach spanning from IoT devices and smart meters to substation automation systems, SCADA platforms and central control systems, with a strong focus on convergence of information and operational technology. Through collaborative projects, pilots and knowledge exchange, these SET Plan groups can foster the development and deployment of secure data models and trusted data-exchange frameworks, thereby strengthening the resilience and security of critical energy infrastructures.

1. INTRODUCTION

The Task Force on 'Digitalisation' focused on integrating digital technologies and ensuring **seamless digital data flows across the economic and social fabric**. This process is crucial to the SET Plan, as it fosters new business models and accelerates **the transition to a low-carbon economy**. Digitalisation acts as an enabler and accelerator across various sectors and services, creating conditions for innovation and opportunities that align with broader EU goals such as sustainability, inclusivity, and competitiveness.

This document provides a set of recommendations for consultation with the wider SET Plan community, beyond the existing Task Force participants. The Annexes of this document include: an overview of the Task Force participants (Annex 1); and the Task Force methodology (Annex 2).

2. KEY EU POLICIES AND INITIATIVES

Digitalisation serves as an enabler and accelerator across different sectors and services, creating conditions for innovation and opportunities that align with broader goals such as sustainability, inclusivity, and competitiveness. The EU policy framework reflects this, tackling digitalisation from different angles and perspectives. Hence, it fosters synergies between digital and green transformations and makes it a key topic for different policy areas.

The SET Plan, as revised through the 2023 Communication (COM(2023) 634), identifies digitalisation as one of five cross-cutting topics requiring dedicated action through time-bound Task Forces. The revised SET Plan aims to align its strategic objectives with the European Green Deal, REPowerEU, and the Green Deal Industrial Plan. It treats digitalisation as a key cross-cutting priority to accelerate the deployment of clean energy technologies and foster European competitiveness. As the technology pillar of the EU's energy and climate policy, the SET Plan coordinates national research and innovation programmes with EU clean energy policy objectives, focusing on strategic autonomy, competitiveness, and decarbonisation.

The European R&I framework provides critical support for the digitalisation of the energy sector. Horizon Europe (2021–2027), the EU's key funding programme for research and innovation, supports digitalisation of energy systems through its Cluster 5 'Climate, Energy and Mobility', with dedicated work programme topics on smart energy systems, advanced grid technologies and digital solutions for the energy transition. According to the European Commission, over EUR 120 million has been allocated under Horizon Europe (2025–2027) to smart energy system topics, including smart substations, advanced distribution management systems, smart energy systems in high-RES scenarios, and control systems based on grid-forming inverters. The Clean Energy Transition Partnership (CETP), a co-funded partnership under Horizon Europe bringing together over 50 national and regional funding agencies across 30 countries, supports transnational R&I projects aligned with the SET Plan through annual joint calls, with topics organised into seven Transition Initiatives covering renewable energy, storage, heating and cooling, and integrated energy systems. Additionally, the Smart Energy Expert Group and the work towards a Common European Energy Data Space provide key governance and strategic direction for the digitalisation of the energy sector.

More broadly, the European Research Area (ERA) framework and the Digital Europe Programme complement Horizon Europe by supporting the deployment of digital infrastructures, AI capabilities, and high-performance computing essential for advanced energy data analysis and system optimisation. National R&I programmes in several Member States also embed digitalisation as a cross-cutting research priority, including by supporting energy data spaces and interoperability infrastructure, thereby further underpinning these EU-level efforts. A list of the key EU policies relevant to this Task Force is listed in the table below. .

Table 1: Key EU policies and initiatives for Task Force 3 (Digitalisation)

Type of policy	Relevant EU policies and initiatives
Cross-sectoral policies	The REPowerEU (2022), The European Green Deal Industrial Plan (2023), The European Green Deal (2020), The Net-Zero Industry Act (2024), Strategic Roadmap for Digitalisation and AI in the Energy Sector (2026)
Energy policies	EU Strategy for Energy System Integration (2020); Digitalising the Energy System - EU Action Plan (2022); The Energy Efficiency Directive (2023); The Renewable Energy Directive (2023); EU Action Plan for Grids (2023); Electricity Market Design Directive (2024); Electricity Market Design Regulation (2024); Energy Performance of Building Directive (2024); Action Plan for Affordable Energy (2025); Electrification Action Plan and European Grids Package (Q1 2026)
Digital policies	The Europe's Digital Decade (2021); The EU Data Act (2024); Data Governance Act (2022); the European Strategy for Data (2020); The EU Cybersecurity Strategy (2020); The Cyber Resilience Act (2022); The Coordinated Plan on Artificial Intelligence (2021), the AI Act (2024), AI Factories Initiative (2025), Data Union Strategies (2025), EU Cloud and AI Development Act (2026), Apply AI (2026)
R&I policies and the SET Plan	Communication on the revision of the Strategic Energy Technology (SET) Plan; Horizon Europe – Cluster 5 'Climate, Energy and Mobility' (2021–2027); Clean Energy Transition Partnership (CETP, 2022–2027); European Research Area (ERA) framework; Digital Europe Programme (2021–2027); Smart Energy Expert Group; Common European Energy Data Space (CEEDS); SET Plan Progress Reports
Other relevant policies	The European Chips Act (2023); The Critical Raw Materials Act (2024), Joint purchasing platform for Critical Raw Materials (2025)

3. RECOMMENDATIONS

Important note: recommendations directly related to Priorities 5 and 6, which cover data-driven services, digital twins, and AI models, as well as other energy use cases such as project assessment and risk analysis, are not included. Based on the outcomes of the TF meetings, no clear solution was identified to serve as the basis for a recommendation. Consultation with Task Force members, as well as a wider set of actors involved in the SET plan, did not yield sufficient additional input to draft further recommendations. Given the high number of recommendations already drafted and revised with multiple inputs, we decided to integrate aspects relevant to these priorities into existing recommendations. Following the consultations with the wider SET Plan community and the discussions at the 3rd Task Force meeting, the recommendations have been further operationalised through dedicated boxes that specify the expected role and actions of ETIPs and IWGs (see Boxes 1–8 below). Furthermore, efforts have been made to strengthen coverage of data-driven services, digital twins, and AI-powered solutions throughout the existing recommendations, as well as of hardware-software system integration, in response to feedback received during the consultation. Task Force members confirmed the focus and approved the approach of further specifying the recommendations in operational terms.

The recommendations below are structured around two layers. The first layer, presented in the shaded boxes (Boxes 1–8), defines concrete and operational actions that fall within the remit of the SET Plan community (specifically the IWGs and ETIPs) and that should be reflected in their Strategic Research and Innovation Agendas (SRIAs), Thematic Visions and Implementation and Investment Commitments (IICs). The second layer, contained in the detailed recommendation tables, provides the evidence base and broader context, identifies systemic challenges, and in some cases gaps that may need to be addressed through other policy processes or by other ecosystem actors (e.g. the European Commission, ACER, national regulators, European Standardisation Organisations). Where recommendations extend beyond the direct competence of the SET Plan, this is noted to ensure clarity on roles and responsibilities.

RECOMMENDATION 1: CREATE COMMON DATA INFRASTRUCTURES WHERE DATA IS ACCESSIBLE, LEADING TO FEDERATED ENERGY DATA SPACES

Recommendation summary:

Energy data across Europe remains fragmented, largely inaccessible, and insufficiently exploited due to unclear data ownership, high digitalisation costs, confidentiality concerns, and cybersecurity risks.

This recommendation supports R&I activities contributing to the creation of common data infrastructures, enabling the gradual emergence of federated energy data spaces.

IWGs, ETIPs, EERA, and CETP are recommended to identify priority data needs, use cases and datasets, while also considering the recommendations from the Smart Energy Expert Group and the framework defined by the Common European Energy Data Space. SET Plan groups should promote collaborative research, pilots, and demonstration projects exploring secure and trusted data exchange across the energy value chain, including cross-sectoral integration with transport, agriculture, and buildings. These activities should support the development of data marketplaces, Artificial Intelligence (AI) tools, advanced analytics and digital twins, contributing to increased renewable energy integration and enhanced cross-sectoral energy system integration

Box 1: Operationalisation of Recommendation 1 – Federated energy data spaces

ETIPs and IWGs should support R&I activities that help create common data infrastructures that make data accessible, enabling the gradual emergence of federated energy data spaces across Europe. This should include integrating energy data with data from adjacent sectors, such as transportation, agriculture, and buildings, through the federation of existing and new data platforms/hubs. Through their Strategic Research and Innovation Agendas (SRIAs), Thematic Visions and Implementation and Investment Commitments (IIC), they should identify priority data needs, use cases, and datasets relevant to the energy sector, while also considering recommendations from the Smart Energy Expert Group and the framework defined by the Common European Energy Data Space. ETIPs and IWGs should promote collaborative research, pilots, and demonstration projects that explore secure and trusted data exchange across the energy value chain. These activities should support the development and exploitation of data marketplaces, as well as the exploitation of digital tools such as AI, advanced analytics, and digital twins, contributing to increased renewable energy integration and enhanced cross-sectoral energy system integration.

WHY

Challenges identified by TF members and literature review

The Green Deal objectives for 2030 and 2050 call for greater, accelerated integration of renewable energy sources and energy storage into the electricity grid, as well as the electrification of end-use sectors, such as heating and mobility. This requires effective grid planning, operation and control of the electricity grid, underpinned by markets for flexibility and demand response, along with seamless data exchange between actors and numerous connected devices, based on common rules and standards.

The ongoing digitalisation of the energy sector rapidly and significantly increases the volume of available data, offering significant potential for innovation and competitiveness in the EU. Despite this, data remains largely unavailable, inaccessible, and/or not usable to its full potential. There are multiple barriers of different natures contributing to this. For example, data ownership and access rights are often not clear. In contrast, high digitalisation costs, together with the lack of clear revenue models for upgrading data infrastructure, may further hinder data availability and accessibility.

Furthermore, a perceived lack of data value creation, concerns about data confidentiality, strategic interests, and uncertainty about the boundaries of the GDPR contribute to data owners' resistance to making data available.

At the same time, there is a need for a robust and reliable digital infrastructure, taking advantage of the spatial and temporal hierarchies, to manage and leverage the already available vast amount of data generated across the energy system, while ensuring seamless integration of numerous new energy assets, such as electric vehicles and heat pumps.

In addition to legal and economic concerns, cybersecurity appears as a major barrier to wider data availability and trust in digital solutions. The energy sector—classified as critical infrastructure—is increasingly vulnerable to cyber threats, and stakeholders may be reluctant to share data without robust safeguards. Therefore, ensuring data protection through advanced encryption, secure interoperability protocols, anonymisation techniques, and secure-by-design architecture is essential.

To address the above, it will be critical to develop a common energy data infrastructure, building on the work of the Smart Energy Expert Group (SEEG) and in coherence with the Common European Energy Data Space (CEEDS) – where data is accessible, secure, reliable and of high quality – laying the foundation for a federated energy data space.

A federated energy data space – aligned with the European Data Strategy[1], the Data Governance Act[2], the Data Act [3], and the Clean Energy Package[4] will therefore connect multiple national, regional, and sectoral platforms under a shared framework that enables trusted, interoperable cross-platform data exchange.

1 https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/european-data-strategy_en
2 https://digital-strategy.ec.europa.eu/en/policies/data-governance-act
3 https://digital-strategy.ec.europa.eu/en/policies/data-act
4 https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52016DC0860

Recent examples have shown how energy data spaces can address challenges in key use cases, such as flexibility management[5] and TSO-DSO coordination[6]. This will also be crucial for integrating intermittent renewable energy sources more effectively, thereby contributing to the objectives of the 'Fit for 55' package[7] and the RePowerEU plan[8].

Finally, a predictable, simplified, and harmonised regulatory environment across Europe is critical to enabling the accelerated deployment of the federated energy data space.

Expected outcomes and contribution to EU priorities

Common energy data infrastructure and federated energy data space, enhanced by integration of data marketplaces, advanced analytics, AI tools and digital twin applications, can:

- **Empower citizens and businesses** to provide seamless access to and make use of granular data for effective delivery of energy services, thereby providing EU citizens and businesses with more control over their energy usage through more informed decisions, active participation in different energy markets, and engagement in demand response/self-consumption initiatives. This, in turn, will increase RES integration, energy efficiency, system resilience and security, and enhance market integration, thereby directly supporting targets under the EU Electricity Directive[9] and Regulation[10] , amended under the EU electricity market design reform[11], the Energy Efficiency Directive[12], the EU Renewable Energy Directive[13] and contributing to the Action Plan for Affordable Energy[14].
- **Accelerate research and development in clean energy technologies and facilitate technology transfer** from research to industry deployment. This will directly contribute to strengthening Europe's clean tech manufacturing capacity and ensuring the EU remains competitive in the global race to net zero, in line with the Net-Zero Industry Act (NZIA)[15] under the EU Green Deal Industrial Plan[16] and the European Competitiveness Compass[17].
- **Enable system-wide optimisation** by integrating energy data spaces with data from adjacent sectors such as water systems, transport and buildings, therefore supporting the EU energy integration strategy[18], the EU action plan on digitalising the energy system,[19] the EU Action Plan for Grids[20] and the upcoming European Grids Package[21] Cross-sectoral data interoperability enables improved planning, real-time operations, and predictive analytics across energy, transport (e-mobility, heating and cooling, and smart building management).

WHAT

- Focus on the **federation of existing platforms/hubs** across multiple use cases and throughout the whole energy value chain to enable cross-platform data sharing for key identified R&D needs.
- **Design a common reference architecture** for national/regional energy data infrastructures, which will be modular, scalable and replicable, leveraging EU initiatives like GAIA-X[22] and European Data Spaces[23] in other sectors (e.g. health) to align infrastructure and trust frameworks.
- **Include layers of governance, semantics, interoperability, privacy and security by design** to define roles and responsibilities, access rights and liability, which will facilitate data pooling, access and sharing and ultimately support the creation of a trusted federated energy data space. A strong governance framework ensuring security, privacy, and data sovereignty should remain central to its development and operation.

5 https://insieme.energy/
6 https://www.entsoe.eu/2024/11/06/data-spaces-in-the-energy-sector-enabling-the-green-energy-transition/
7 https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/delivering-european-green-deal/fit-55-delivering-proposals_en
8 https://commission.europa.eu/topics/energy/repowereu_en
9 https://eur-lex.europa.eu/eli/dir/2019/944
10 https://eur-lex.europa.eu/eli/reg/2019/943
11 https://energy.ec.europa.eu/topics/markets-and-consumers/electricity-market-design_en
12 http://data.europa.eu/eli/dir/2023/1791/oj
13 https://eur-lex.europa.eu/eli/dir/2023/2413
14 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52025DC0079
15 http://data.europa.eu/eli/reg/2024/1735/oj
16 https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/green-deal-industrial-plan_en#paragraph_33964
17 https://commission.europa.eu/topics/eu-competitiveness/competitiveness-compass_en
18 https://energy.ec.europa.eu/topics/eus-energy-system/energy-system-integration_en
19 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52022DC0552
20 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52023DC0757
21 https://energy.ec.europa.eu/news/commission-collects-views-preparation-european-grids-package-2025-05-13_en
22 https://gaia-x.eu/
23 https://digital-strategy.ec.europa.eu/en/policies/data-spaces

- **Promote ecosystem growth** through integration of data marketplaces, advanced analytics, AI tools and digital twin applications over the federated data space.
- **Support the integration of the energy data spaces with other non-energy data spaces** (for example, agriculture, R&I, mobility, etc.)
- **Encourage the development of a harmonised monitoring framework** for digital energy infrastructure in the EU, necessary to support the creation of a common data infrastructure (e.g. NRAs will soon be able to monitor and evaluate the performance and efficiency of electricity smart grids across the EU through the definition of common indicators, in line with the EU Action Plan on Digitalising the Energy System[24] and the EU Electricity Directive[25]).

WHO

The development of a common data infrastructure and federated data space applies to all IWGs and ETIPs, and would require the active involvement of many types of stakeholders, such as:

- **Academia/research organisations:** Federated data spaces and shared data infrastructures provide researchers access to effective datasets for research across areas such as energy systems modelling, integration of renewable energies, and energy efficiency, but also foster collaboration with industry and support education and training. The role of academia is key in mapping and recommending infrastructures that would benefit from federation, as well as in developing data analytics tools and AI models based on specific datasets.
- **Industry stakeholders** (e.g. TSOs/DSOs) can likewise leverage shared energy data infrastructure to maximise efficiency and reduce the operating cost through, for example, predictive maintenance and improved asset management. Their role could include leading the design and operation of national/regional interoperable energy data hubs/platforms, publishing priority datasets.
- **National and EU governments, and regulators** could play a role in **defining the legal and regulatory** frameworks for secure data space and data sharing or providing guidance to ensure coherence among existing initiatives. As a result, they can make better policy decisions, improve market regulation, and implement targeted policy interventions in renewable energy integration, energy efficiency, and energy grid resistance and stability.
- Citizens and consumers also have a critical role in contributing to and benefiting from energy data ecosystems. Federated data spaces should include mechanisms for user consent management, individual data ownership rights, and incentives for households and consumers to share data (e.g., from smart meters, home storage, and EVs). This will not only empower citizens but also generate valuable decentralised data streams to support grid flexibility, demand-side response, and localised energy services.

HOW

Actions that can be taken by the IWGs and ETIPs include:

- **Integrating R&I activities on common energy infrastructures** into Thematic Visions, IICs and SRIAs of the IWGs and ETIPs, respectively. This includes: definition of R&I roadmap for the federated energy data space; identification of relevant existing energy data platforms/hubs and associated stakeholders (data providers/users); definition of key use cases for each SET Plan technology, including cross-sector applications such as electricity and heating & cooling — for example, optimisation of hybrid systems combining solar thermal and heat pumps to support the identified R&I needs; specification and differentiation between data types and dataset priorities (original data/aggregated data, historical/real-time, spatial - temporal hierarchies of data) In addition, special attention should be given to the unique needs of high-risk sectors like nuclear safety, as well as to integrating legacy systems into the energy data space, in line with EU frameworks, such as the Data Act and NIS2 Directive[26].**Including R&I activities on integrating advanced analytics, AI tools and digital twin applications** using common data infrastructure and federated data space into Thematic Visions, IICs and SRIAs of the IWGs and ETIPs, respectively.

24 https://energy.ec.europa.eu/topics/eus-energy-system/digitalisation-energy-system_en
25 https://eur-lex.europa.eu/eli/dir/2019/944
26 https://eur-lex.europa.eu/eli/dir/2022/2555

- Organising **multi-stakeholder co-design workshops** at national and EU level to identify gaps in interoperability, security and governance and align stakeholders on their different needs, also learning from other sectors (e.g. health energy data space).
- **Supporting testing and validation through pilots and regulatory sandboxes[27]/living labs** – this includes interoperability, real-world testing at the early prototype stage, P Connectathon[28] among public and private actors, and with other common European data spaces; a code of conduct for energy-smart appliances to enable interoperability and boost their participation in demand response schemes[29]); cross-border pilot projects (e.g. EU-SysFlex[30] and Estonian Estfeed[31] projects for the provision of cross-border flexibility services.
- **Connecting with and building on results/learning from the ongoing EU projects on common energy data spaces**, IntNET[32] OMEGA-X, Enershare, Synergies, Data cellar, INSIEME[33] and federated digital twins (e.g. TwinEU), EDDIE[34], Enershare[35], Synergies[36], Data cellar[37] federated digital twins (e.g. TwinEU[38]).
- **Guiding different R&I calls** under Horizon Europe and the Clean Energy Transition Partnership (CETP) towards large-scale projects focusing on building the core components of this federated infrastructure (e.g., the trust framework, the common data model, reference implementations of data space connectors).

WHEN

Short term (2026-2027) to medium term (2027-2030):

- **2026:** Include the creation of more common energy data infrastructures in the R&I activities of the IWG Thematic Visions, IICs and SRIAs to support the development of federated energy data spaces and leverage existing projects and initiatives in the Member States or at the European level.
- **2026-2027:** Collaboration with Member States on common European energy data infrastructures to support the creation of a federated energy data space as a cornerstone of the EU's strategy to digitalise the energy system (under the European Data Strategy[39] and the EU Action plan on digitalising the energy system[40]).
- **By 2030:** Deploy key projects focusing on common energy infrastructures and federated energy data spaces.

KEY PERFORMANCE INDICATORS (KPIS)

Proposed KPIs to monitor implementation include:

- Number of existing energy platforms/hubs federated (e.g. OneNET[41] Project Pilot integrates EUniversal[42], CoordiNet[43] and INTERFACE[44] pilots to enable cross-border flexibility services.
- Number of stakeholders with access to a common energy data infrastructure (e.g. national smart meter hub)
- Percentage increase of data assets accessible and reusable through a common energy data infrastructure
- Number of tools (e.g. digital twins applications, advanced analytics, AI tools) integrated into a common energy infrastructure.
- Level of digital investments in the energy sector at national/EU level to track progress, assess impact on different policy objectives and communicate benefits.

27 https://op.europa.eu/en/publication-detail/-/publication/c2da0ca3-c867-11ed-a05c-01aa75ed71a1
28 https://connectathon.ihe-europe.net/
29 https://joint-research-centre.ec.europa.eu/jrc-news-and-updates/energy-smart-appliances-launch-eu-code-conduct-interoperability-2024-04-23_en
30 Pan-European system with an efficient coordinated use of flexibilities for the integration of a large share of RES | EU-SysFlex | Project | Results | H2020 | CORDIS | European Commission
31 https://x-road.global/xroad-case-studies-library/2024/10/21/access-to-electricity-and-gas-smart-meter-data-in-estonia-powered-by-x-road-technology
32 https://intnet.eu/
33 https://insieme.energy
34 https://eddie.energy/
35 European commoN EneRgy dataSpace framework enabling data sHaring-driven Across- and beyond- eneRgy sErvices | ENERSHARE | Project | Fact Sheet | HORIZON | CORDIS | European Commission
36 https://synergies-project.eu/
37 https://datacellarproject.eu/
38 https://twineu.net/
39 https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/european-data-strategy_en
40 https://energy.ec.europa.eu/topics/eus-energy-system/digitalisation-energy-system_en
41 https://cordis.europa.eu/project/id/957739
42 https://cordis.europa.eu/project/id/864334
43 CoordiNet - E.DSO
44 https://cordis.europa.eu/project/id/824330

RECOMMENDATION 2. DEVELOP DATA SHARING INCENTIVES FOR DATA HOLDERS

Recommendation summary:

Despite rapidly growing volumes of energy data, much remains unshared due to confidentiality concerns, strategic positioning, underestimation of data value and a lack of digital skills.

This recommendation supports R&I actions aimed at identifying and testing data sharing incentives for data holders, enabling the development of data valorisation mechanisms within the energy sector.

IWGs, ETIPs, EERA, and CETP are recommended to explore approaches that demonstrate the value of shared energy data through collaborative projects, pilots, and knowledge exchange initiatives. This should include exploiting the portfolio of incentive mechanisms for data sharing and increasing awareness of the Data Act. They should also support the use and development of AI tools, digital twin applications, data marketplaces, and cross-sectoral data spaces. These activities should support the development of digital services that accelerate renewable energy integration, enable consumer participation, and improve the energy performance of buildings and distribution grids.

Box 2: Operationalisation of Recommendation 2 – Data sharing incentives

ETIPs could participate in the Innovation Action D3-23 ("Data sharing to support the training and development of AI foundation models in the energy sector") to identify and test data-sharing incentives for data holders, thereby enabling the development of data valorisation mechanisms within the energy sector. Through collaborative projects, pilots and knowledge exchange initiatives, they could explore approaches that demonstrate the value of shared energy data by exploiting the portfolio of incentive mechanisms for data sharing, increasing awareness of the Data Act, and supporting the use and development of AI tools, digital twin applications, data marketplaces and cross-sectoral data spaces, to facilitate value extraction from shared data. Given that the need for incentives for data sharing is already well understood, IWGs (particularly those following ETIP-SNET, ETIP-Wind and ETIP-PV) could, in parallel with the ETIPs' work, get their Member States to provide the incentives through regulation, such as applying a sharing requirement as a non-price criterion in auctions for public renewable energy support.

These activities could also support the development of digital services that accelerate renewable energy integration, enable consumer participation, improve the energy performance of buildings and distribution grids through distributed energy sources, and enhance the productivity of RES installations. By analysing data value-creation models and testing data-sharing approaches in real-world contexts, ETIPs and IWGs can help build trust among stakeholders and support the emergence of innovative data-driven energy services.

WHY

Challenges identified by TF members and literature review

The ongoing digitalisation of the energy sector rapidly and significantly increases the volume of available data, which represents a valuable resource for innovation and competitiveness in the EU. Despite this, data remains largely unavailable, inaccessible, and/or not usable to its full potential.

The European Commission has long recognised that Europe's data represents a 'vast but underutilised pool.' It has emphasised that access to and sharing of data are major drivers of competitiveness and that existing data legislation, such as the Data Act and the Data Governance Act, should serve as the foundation for a broader, more integrated Data Union Strategy. Artificial intelligence is seen as a key enabler, capable of supporting the planning, optimisation, and predictive maintenance of energy grids, assets, and consumption.

In the energy sector, the EU Action Plan on the digitalisation of the energy system[45] since 2022 has stressed the importance of data access, data sharing and standardisation to enable digital energy services, but it has also acknowledged that the full potential of energy data remains largely untapped and underutilised.

Indeed, there are many obstacles to bringing the data together: confidentiality, including fear of non-compliance with GDPR, and strategic positioning reasons[46] and a certain underestimation of the data's value – often influenced by factors such as the type of organisation, level of digital maturity, and participants' ability to generate individual or collective value through concrete use cases. In addition, available data are often low in granularity or of insufficient quality – for example, due to a lack of smart metering systems with advanced functionalities – to support value creation.

To these must be added the lack of digital skills[47], incompatibility of data formats (i.e. poor 'interoperability') and lack of trust in data quality[48].

Many of these obstacles may be overcome by providing an incentive to the sharer (monetary or non-monetary) and by reassuring the sharer that the data will be handled per the terms agreed between the sharer and the recipient[49].

Expected outcomes and contribution to EU priorities

Providing access to a greater volume of granular energy data could unlock new energy services and innovative business models, while supporting the energy system and enhancing EU competitiveness.

The insights derived from large datasets may be used in the following ways:

- **Accelerate the integration of RES** by allowing better predictions of energy demand, supply, imbalance, grid congestion, and prices, thereby supporting decarbonisation targets under the European Green Deal[50] and the REPowerEU[51].
- **Empower consumers (whether isolated or grouped in energy communities)** to make informed choices about when to consume, when to consume what they may produce on-site and when to export any on-site production. In doing so, they can engage in demand response/collective self-consumption initiatives or participate in different electricity markets by providing flexibility services. This, in turn, supports efficient and sustainable grid operation and contributes to the objectives of the Clean Energy for All Europeans Package[52].
- Enabling diverse actors, such as system operators, startups, energy communities/aggregators, and public authorities, to **develop innovative data-driven solutions that leverage digital technologies** to enhance **efficiency, interoperability and resilience across the energy value chain**. This way, it contributes to the strengthening of Europe's capacity to produce advanced technologies such as smart grids, renewable energy systems, and energy storage solutions (NZIA Regulation[53]).
- **Minimise the costs of grid enhancements and enhance system resilience** through better forecasting techniques and real-time grid operation and management, as well as efficient methods for activating demand-side flexibility. (EU Action Plan for Grids[54]).
- **Achieve understanding of performance of renewable energy generation assets to:** detect anomalies in plant performance and advise on likely causes; optimise intervals for plant repairs and pinpoint the cost-optimal repair; and provide insights into the optimal combinations of subcomponents in a plant and into plant layout
- **Achieve understanding of energy performance of buildings** – the Data Act, in conjunction with Article 16 (Data Exchange)[55] of the Energy Performance of Buildings Directive,[56] should allow, with actual energy consumption (meter data) for Energy Performance Certificates and with Big Data, for better choices or combinations of building design, materials, HVAC technology, and operation protocols for those technologies to be determined.

45 https://energy.ec.europa.eu/topics/eus-energy-system/digitalisation-energy-system_en
46 M. Fremouw, A. Bagaini, P. de Pascali, 'Energy potential mapping: open data in support of urban transition planning', Energies, 2020 (13) (2020), p. 1264
47 Wolff, Annika; Gooch, Daniel; Mir, Umar; Cavero, Jose and Kortuem, Gerd (2015). Removing barriers for citizen participation to urban innovation. In: Digital Cities 9, 27 Jun 2015, Limerick
48 Data may have low granularity – for example due to lack of smart metering systems with advanced functionalities
49 D2.1 "1st version of SYNERGIES Requirements and Detailed Architecture Design, available at: https://energydataspaces.eu/public-deliverables/
50 https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en
51 https://commission.europa.eu/topics/energy/repowereu_en
52 https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52016DC0860
53 https://single-market-economy.ec.europa.eu/industry/sustainability/net-zero-industry-act_en
54 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52023DC0757
55 https://energy.ec.europa.eu/document/download/6f7e3300-dee9-4c32-b73e-079676ed7d6e_en?filename=Data%20exchange%20%28Article%2016%29%20-%20annex%206.pdf
56 https://eur-lex.europa.eu/eli/dir/2024/1275/oj/eng

WHAT

The SET Plan actors and Member States should work to make large volumes of data available to parties with a legitimate interest and under appropriate conditions by:

- **Supporting the development of a portfolio of incentive mechanisms for data** sharing for different types of stakeholders and across multiple identified use cases.
- **Increasing awareness of the Data Act**, encouraging its provisions on access to and sharing of data from connected systems to be used by many stakeholders.
- Using the Common European Energy Data Space (CEEDS) as a hub to access datasets, or in the absence of a CEEDS, **support comprehensive data governance policies** that clearly define data ownership, access rights, and usage limitations, to guarantee that data holders retain control over their data.
- **Supporting the development of AI tools, digital twins applications and data marketplaces** and **cross-sectoral data spaces** to facilitate value extraction from the shared data.

WHO

The recommendation applies to:

- **All ETIPs/IWGs of the SET Plan** to integrate the R&I actions of this recommendation into their SRIAs, IICs and Thematic Visions.
- **EU/national governments and regulators** can leverage increased energy data access to create value by enabling effective energy market operation and provision of increased transparency and choice for businesses and citizens.
- **Industry actors**, such as DSOs and TSOs, can benefit from the opportunity to achieve electricity network operational efficiencies, business model innovation, and ultimately new customer-centric services by leveraging access to data from a wide range of sources.
- **Startups and SMEs** can leverage access to data to disrupt conventional business models, innovate energy solutions, and scale new business models, thereby improving energy market competitiveness and lowering costs.
- **Academia/research organisations** can leverage access to diverse, high-quality datasets for more accurate modelling, developing data analytics tools and AI models for system optimisation across different sectors, like electricity, heating, cooling, and mobility.

HOW

Actions that can be taken by the IWGs and ETIPs include:

- **Integrating R&I activities on different types of incentives for data sharing across high-value use cases** identified by the ETIPs and IWGs – For example: 1) Data as a Service (DaaS)[57] or direct monetisation, where organisations pay for access to specific high-value data (e.g. real-time data for flexibility services); 2) non-financial/beyond financial for citizens/communities (e.g. community benefits through collective energy efficiency, environmental impact, social innovation, etc.); 3) Regulatory incentives, where the national regulators allow regulated entities like DSOs and TSOs to include investments regarding data sharing platforms in their regulated asset base. Similarly, in other highly regulated sectors, such as nuclear safety, incentives could focus on promoting data sharing for operational safety, asset integrity, and predictive maintenance, offering financial incentives for R&I projects in which data contributions could lead to faster regulatory consideration of new technologies. 4) Finally, Member States can specify an operational data sharing criterion in their auctions for public RES support[58],[59] or national Laws mandate that data related to public safety become publicly available (e.g. in the Netherlands, mining exploration data becomes publicly available 5 years after acquisition). In this regard, incentives should be tailored to the type of data, for example, distinguishing between high-value commercial data and data relevant to public safety or innovation.
- **Guiding Horizon Europe funding** towards pilot projects that specifically test different data sharing incentive models in a real-world environment or demonstrate significant innovation/safety improvements using shared data related to critical infrastructure. In addition, mandatory data-sharing clauses (e.g. public safety data for geothermal projects) can be included for those projects, and similar practices can be encouraged at the Member State level.
- **Supporting the development of a 'Data Value Toolkit'** for different stakeholders, which would include methodologies for assessing the potential value of various datasets and models to support the design of data sharing agreements.
- Organising **multi-stakeholder co-design workshops** at national and EU level to identify gaps in interoperability, security and governance and align stakeholders on their different needs, also learning from other sectors (e.g. health energy data space).
- **Promoting testing and validation through pilots and regulatory sandboxes[60]/living labs** to communicate the collective benefits of data sharing, therefore demonstrating the potential for innovation and value creation. The main challenge lies in assessing a dataset's value before its use, highlighting the need for clear data valuation methodologies to support the above-mentioned incentive models. Testing innovative data-sharing mechanisms in real-world settings, such as through regulatory sandboxes, is therefore essential.
- **Promoting governance mechanisms** based **on data sovereignty** and supported by legal, contractual, and technical measures. Governance must ensure granular, auditable access control and automatic enforcement of data usage policies through technologies such as smart contracts. Standardised legal frameworks are critical to protecting intellectual property, ensuring compliance, and fostering trusted data sharing and broader innovation.
- **Support training and toolkits to increase digital literacy** among all types of stakeholders.

57 DaaS refers to a business model where data is delivered on demand and accessed remotely, often through the cloud, instead of being stored and managed locally.

58 For example, an owner of a wind/ PV park may agree to share operational data with a defined group of stakeholders, and in turn, will be compensated for this service by being able to bid higher than if no such criterion was applied (e.g. NZIA Implementing Regulation).

59 Member States may be encouraged to call for operational data sharing as a requirement (or bonus) in some auctions for public RES support, as in the case of the US DoE Solar Data Bounty Prize).

60 https://op.europa.eu/s/z8bS

WHEN

Short term (2026-2027) to medium term (2027-2030)

- **2026:** Integrate activities on data value co-creation in the R&I activities of the IWG Thematic Visions, IICs and ETIP Strategic Research and Innovation Agendas to support the development of data valorisation mechanisms.
- **2026:** First example of a Member State public support scheme for renewable energy generation requiring beneficiaries to share detailed operational data about their installations as a condition for receiving support.
- **2026-2027:** Collaboration with Member States on development of data valorisation mechanisms, also including regulatory experimentation (e.g. using regulatory sandboxes).
- **By 2030:** Deploy key projects focusing on data value co-creation and valorisation mechanisms.

KEY PERFORMANCE INDICATORS (KPIS)

- Proposed KPIs to monitor implementation include:
- Number of public support schemes for renewable energy that include requirements for sharing specified plant operational data, along with details on the entities with whom the data must be shared, as a condition for receiving support; the total capacity (in MW and/or GWh) covered by these schemes; and the number of Member States currently piloting or implementing such initiatives.
- Number of requests for access to data from connected energy systems under the Data Act and the number of times that data is transferred.
- Number of user accounts on the Data Space and volume of data transacted through the Space, including its growth over time.
- Number of data holders sharing data in pilots/testbeds at national/EU level
- Stakeholder satisfaction (e.g. percentage of data holders willing to continue sharing data).
- Number of non-energy sectors that benefit from a common energy infrastructure/a federated energy data space (e.g. number of new services created across different sectors).
- Business model viability (use-case specific KPIs, for example, reduction of the operation and maintenance cost of wind/PV systems; percentage of energy cost reduction, percentage of carbon emission reduction, etc.).

RECOMMENDATION 3: CREATE COMMON INTEROPERABILITY STANDARDS FOR SMART METERS, LEADING TO PAN-EU SMART METERING STANDARDS INITIATIVES

Recommendation summary:

Europe's smart metering landscape remains deeply fragmented, with inconsistent adoption of standards, proprietary protocols and varying functionalities across Member States, limiting consumer empowerment and cross-border energy services.

This recommendation supports R&I activities that exploit common interoperable approaches for smart metering systems across Europe.

IWGs, ETIPs, EERA, and CETP are recommended to support activities that demonstrate how interoperable smart metering enables real-time access to energy information, facilitates demand response and flexibility markets, and supports the development of consumer-centric digital energy services. Through coordinated R&I actions, SET Plan groups can also explore how smart meter data can support renewable energy integration, reduce peak demand and improve efficiency across the European energy system.

Box 3: Operationalisation of Recommendation 3 – Interoperability of smart metering systems

ETIPs and IWGs should support R&I activities that leverage common, interoperable approaches to smart metering systems across Europe. These activities can demonstrate how interoperable smart metering data enables real-time access to energy information, facilitates participation in demand response and flexibility markets, and supports the development of consumer-centric digital energy services. Through coordinated R&I actions, ETIPs and IWGs can also explore how smart meter data can support renewable energy integration, reduce peak demand and improve energy efficiency across the European energy system.

WHY

Challenges identified by TF members and literature review

The European landscape for smart meters remains deeply fragmented in both technology and functionality. In some regions, smart meters are still first-generation devices that provide only monthly or daily readings, with no capacity for remote updates or dynamic tariffing. In others, they support richer features but rely on proprietary protocols and custom data models, locking consumers, utilities, and third-party providers into siloed ecosystems.

A core technical challenge lies in the inconsistent adoption and interpretation of standards. The DLMS (Device Language Message Specification)/COSEM (Companion Specification for Energy Metering) suite (IEC 62056 series) is generally regarded as a suitable, object-oriented solution for electricity, gas, heat, and water metering.[61] Yet, in the absence of pan-EU profiles, vendors and system integrators use only fragments of the standard, leading to widespread incompatibilities that hinder interoperability.

Beyond protocol variations, there are discrepancies in the functions implemented. Some meters feature real-time data access and dynamic tariff capability, while others do not. This inconsistency creates asymmetries in consumer empowerment and limits cross-border energy services. Furthermore, consumer data rights differ significantly.[62]

The standardisation of smart meter functionalities also introduces elevated cybersecurity and data protection risks. Without harmonised security protocols, smart meter data could be subject to interception, misuse, or manipulation. A secure-by-design approach is essential to ensure that common standards incorporate robust encryption, secure key management, mutual authentication, and regular patching protocols. The standardisation of smart meter functionalities is directly linked to the Electricity Market Design, which requires granular data for consumer participation. It is a core enabler for the Digitalising the Energy System Action Plan and is essential for fulfilling the cybersecurity requirements of the NIS2 Directive at the grid edge.

61 International Electrotechnical Commission (IEC). IEC 62056-5-3:2023 — Electricity metering data exchange — The DLMS®/COSEM suite — Part 5-3: DLMS®/COSEM application layer. Link: https://webstore.iec.ch/en/publication/67915

62 European Union. Directive (EU) 2019/944 of 5 June 2019 on common rules for the internal market for electricity. Official Journal of the European Union. Link: https://eur-lex.europa.eu/eli/dir/2019/944/oj

Expected outcomes and contribution to EU priorities

Implementing harmonised interoperability standards for smart meters across Europe will generate transformative outcomes. Consumers in every Member State will be equally able to access high-resolution consumption data and real-time service interfaces, enabling them to enrol in dynamic tariff plans, use energy-saving dashboards, and access third-party services.

If implemented, this recommendation can favour the integration of renewables, reduce peak generation and grid reinforcement needs, preserve energy expenditure, and help meet EU targets for carbon reductions. It can also empower digital twins and AI to optimise grid performance and monitor it using high-frequency, reliable data.

A harmonised standard will reduce vendor lock-in. Manufacturers producing interoperable meters will have easier access to the EU internal market, increasing competition and reducing costs.[63] Utilities that require certified, interoperable meters will avoid custom system integrations and reduce total cost of ownership.

Service and technology innovators, including software developers and aggregators, will benefit from a single, pan-European smart meter API.

Harmonised meter standards enhance grid resilience thanks to real-time data from smart meters.

While electricity metering is the initial priority, interoperability standards should be future-proofed for multi-utility metering, encompassing gas, heat, and water systems. Standardising across sectors will enable integrated services, such as combined energy and water-efficiency analytics, dynamic billing, and real-time leakage detection, while reducing utilities' operational costs.

WHAT

Develop and adopt common interoperability standards for smart metering systems across Europe, ensuring that all new (and future upgraded) smart meters support a core set of advanced functionalities and speak a "common language." This involves defining a unified framework – building on existing standards – that covers: a common data model for meter information, standard communication protocols/APIs (at the application level) for exchanging real-time consumption and feed-in data, and standardised functional requirements that every smart meter should fulfil. The interoperability standards should, as far as possible, be compatible with the national standards currently adopted.

Standards at four distinct layers should be defined to ensure true interoperability:

1. **Functional Layer:** A mandatory baseline of functionalities for all new smart metres (e.g., near real-time data access at 15-minute or finer resolution, support for dynamic tariffs, bi-directional communication).
2. **Semantic Layer:** A common data model, based on established standards like DLMS/COSEM and the Common Information Model (CIM), to ensure data is understood consistently across all systems.
3. **Application Layer:** A standardised, open Application Programming Interface (API) that allows authorised third parties to access data and interact with the meter in a uniform way across the EU. This is the key to unlocking innovation in energy services.
4. **Security Layer:** A common, robust cybersecurity framework based on a "security-by-design" principle, including end-to-end encryption and secure authentication protocols. Given the challenge posed by legacy systems and the vast installed base of first-generation, non-interoperable smart metres, the strategy must include a clear, cost-effective migration path for these legacy assets.

63 European Union. Directive (EU) 2019/944 of 5 June 2019 on common rules for the internal market for electricity. Official Journal of the European Union. Link: https://eur-lex.europa.eu/eli/dir/2019/944/oj

Key functionalities to standardise include:

- Near real-time data exports at intervals of 15 minutes or finer, accessible via a secure, standardised API.
- Bi-directional communication supporting tariff updates, remote firmware updates, and demand-response signals.
- Dynamic tariff and billing support, including time-of-use registers and critical peak pricing.
- Consumer and third-party access via a standardised interface, programmable via open APIs.
- Harmonisation with gas, heat, water meter and meteorological data structures to support integrated energy services.
- Security by design, according to the implementing regulation.[64]

WHO

The work would be coordinated by the European Commission and made formal by the European Standardisation Organisations: CEN, CENELEC, ETSI, ETIPs and IWGs.[65] These organisations, based on the existing Smart Meters Coordination Group, would issue a harmonised technical specification to enable interoperability between existing deployments.[66] The specification would include directives for voluntary alignment of legacy multi-utility protocols, using models for gas and heat metering, so that unified applications can consume meter data across all utilities. IWG could ensure that any proposed digital standards and protocols comply fully with safety regulations and provide expert input on the critical safety functions that digital systems must support.

ETIP SNET will act as the technical advisor and industry coordinator for this initiative to ensure the resulting standards are practical, fit-for-purpose, and supported by the key stakeholders who will implement them.

Specific Actions for ETIP SNET:

1. **Define the Technical Requirements:** The Technical Requirements will lead the technical working groups responsible for defining the mandatory functional requirements, the common data model, and the standardised API specifications. Its members, the TSOs, DSOs, and manufacturers, are the experts who know what is technically feasible and operationally necessary.

2. **Coordinate Cross-Border Pilot Projects:** Before a standard is finalised, it must be rigorously tested. ETIP SNET will coordinate large-scale, cross-border pilot projects with our members to validate the proposed standards in real-world, multi-vendor environments, ensuring they work in practice.

3. **Build Industry Consensus:** As a neutral platform, it will act as the honest broker between different industry stakeholders (e.g., competing manufacturers, TSOs, and DSOs) to build the consensus needed for a single, unified European standard.

The SET Plan should drive this with a clear mandate and a structured process:

1. **Provide R&I inputs to support standardisation:** the SET Plan should recommend that the European Commission consider launching a dedicated "Smart Meter Interoperability Task Force" under the Smart Energy Expert Group, and should provide R&I evidence and technical inputs from ETIPs and IWGs to inform its work.

2. **Collaborative Standardisation:** this Task Force, co-led by the Commission and a key industry body like ETIP SNET, should bring together European Standardisation Organisations (CEN, CENELEC, ETSI), ACER, and national regulators to develop the technical specifications.

3. **Make it binding:** the SET Plan must advocate for the final technical specification to be made legally binding through an Implementing Act under the Electricity Directive. A voluntary approach has proven insufficient to overcome market fragmentation. This act would make the standard mandatory for all new and replacement metres procured after a certain date.

64 Commission Implementing Regulation (EU) 2023/1162 of 6 June 2023 on interoperability requirements and non-discriminatory and transparent procedures for access to metering and consumption data. Official Journal of the European Union. Link: https://eur-lex.europa.eu/eli/reg_impl/2023/1162/oj

65 CEN-CENELEC. Smart Meters — overview page (standardisation activities supporting interoperability of metering systems). Link: https://www.cencenelec.eu/areas-of-work/cen-cenelec-topics/smart-grids-and-meters/smart-meters/

66 European Commission. Standardisation Mandate M/441 to CEN, CENELEC and ETSI for an open architecture for utility meters. Link: https://www.cencenelec.eu/media/CEN-CENELEC/AreasOfWork/CEN-CENELEC_Topics/Smart%20Grids%20and%20Meters/Smart%20Meters/m441_en.pdf

Member States would be required, through national regulators such as ACER, CEER, and NRAs, to integrate these interoperability standards into their national roll-out programs and make compliance mandatory for all new smart meter installations. Utilities and DSOs would integrate the standard into procurement documents, upgrade their meter data management systems and data hubs, and publish APIs for consumer and third-party access. Meter manufacturers and IoT platform vendors are expected to secure a Europe-wide conformity certification, marking their devices as "Interoperable Smart Meters," guaranteed to work across markets. National regulators would embed standards in grid codes and meter installation rules, requiring compliance with those standards for all new and replacement meters. Research institutions and ETIPs/IWGs would support R&I on advanced features of smart metering systems, pilot deployments, and compliance testing frameworks. Consumer groups and aggregators would collaborate on API usability, data privacy, and information/access provisions. Interoperability is also being addressed within the CETP framework; cooperation and alignment with ongoing efforts are recommended.

HOW

This proposed framework mandates adherence to a common data model, leveraging DLMS/COSEM specified in the IEC[67] series for electricity metering and, where relevant, extending to gas, heat, and water meter domains through standardised capabilities or harmonised DLMS objects. Communication protocols include OBIS (Object Identification System) code usage for data elements and clearly defined APIs enabling both data retrieval and control commands. These interfaces must support at least 15-minute data resolution and enable remote signal delivery, whether for pricing updates, firmware patches, or load control commands. Security mechanisms must be enforced by design, incorporating encryption algorithms and authentication methods consistent with Commission Implementing Regulation 2023/1162[68] and DLMS/COSEM security suites.

Practical implementation includes a phased schedule. The Commission could convene a "Smart Meter Interoperability Task Force" within the Smart Energy Expert Group to define minimum functionality and technical profiles. Behind it, Member States could provide pilots through existing smart meter deployments and data hubs in selected countries. National regulations would begin to reflect the mandatory use of the interoperable standard for all new installations. Certification regimes could be fully operational, and utilities would begin to retrofit legacy meters with external interfaces or integrated upgrades. New user-facing services would launch on top of the shared foundation. Most households could have truly interoperable, advanced meters that support consumer-driven services and system-level digitalisation.

Member States can align existing deployments with new interoperability standards without creating excessive transition costs through a pragmatic, three-tiered approach:

1. **Mandate for the Future:** The new interoperability standard should be made mandatory only for all new and replacement meters. This ensures a gradual, cost-effective transition as the existing meter population reaches its natural end of life. This "grandfathering" approach avoids the massive cost of replacing millions of recently installed functional meters.

2. **Interoperability at the Data Hub Level:** For existing, non-compliant smart meters, interoperability can be achieved at a higher level. Member States should mandate that central data hubs, or "head-end systems," that collect data from these meters expose a standardised, common API to the market. This creates a "wrapper" or "adapter" that translates proprietary protocols into the common European standard, providing access to the data without replacing the physical meter.

3. **Incentivise Low-Cost Retrofit Solutions:** The EU should fund R&I into low-cost, certified hardware modules (sometimes called "dongles") that can be retrofitted to existing meters to provide the required standardised data interface. This offers a cost-effective upgrade path for specific use cases where near-real-time local data is essential.

In addition, ETIPs and IWGs should identify and prioritise specific R&I gaps related to smart metering interoperability, including: testing and validation of interoperability profiles across multi-vendor environments; development of low-cost retrofit hardware modules for legacy meters; R&I on cybersecurity-by-design for next-generation metering infrastructure; and pilot projects demonstrating how interoperable smart meter data can enable new flexibility and demand response services. These R&I priorities should be reflected in the respective SRIAs, Thematic Visions and IICs.

The transition can be managed through a phased approach. Regulatory exemptions for pilot projects could be used to test new standards in controlled environments. Financial support and long-term planning, as part of the SET Plan, could also help operators with the transition costs.

67 International Electrotechnical Commission (IEC). IEC 62056-6-1:2023 — Electricity metering data exchange — The DLMS®/COSEM suite — Part 6-1: Object Identification System (OBIS). Link: https://webstore.iec.ch/en/publication/67916

68 Implementing regulation - 2023/1162 - EN - EUR-Lex

WHEN

Short term (2026-2027) to medium term (2027-2030)

- **2026:** Integrate activities on interoperability standards for smart metering systems in the R&I activities of the IWG Thematic Visions, IICs and ETIP SRIAs to support the development of common interoperability standards for smart metering systems.
- **2026-2027:** Collaboration with Member States on the development of common interoperability standards for smart metering systems, also including regulatory experimentation.
- **By 2030:** Deploy key projects focusing on the applications of the developed common interoperability standards for smart metering systems (i.e. interoperable services; dynamic tariff take-up available for EU citizens).

KEY PERFORMANCE INDICATORS (KPIS)

Proposed KPIs to monitor implementation include:

- The percentage of Member States referencing the standard in meter installation codes;
- Percentage of installed smart meters with real-time data and APIs exposed;
- Number of interoperable meter models certified;
- Percentage of users with potential to subscribe to dynamic tariffs; and
- Peak demand change measured in line with flexibility take-up.
- Share of consumers accessing real-time consumption data weekly/monthly.

Consumer feedback and satisfaction surveys should also reflect greater empowerment and efficiency gains across the population.

RECOMMENDATION 4: PROMOTING COMMON DATA STRUCTURES AND STANDARDISATION IN THE ENERGY SECTOR, LEADING TO COMMON DATA MODELS IN ENERGY

Recommendation summary:

The continued use of proprietary data formats and stand-alone data models across the European energy industry prevents end-to-end integration, raises costs, and blocks key applications such as grid integration of electric vehicles, digital twin deployment and real-time demand response.

This recommendation supports R&I activities that promote the use of common data structures within the energy sector, including shared energy data models to ensure semantic interoperability across electricity, heating, cooling, water, gas and e-mobility.

IWGs, ETIPs, EERA, and CETP are recommended to test interoperable data architectures through collaborative projects and cross-sector pilots. Herein they could rely on unified Application Programming Interfaces (APIs) to enable secure, standardised data exchange between platforms and stakeholders. Such efforts will improve data usability for digital energy applications and enable innovative services such as e-mobility solutions, smart building services, flexibility services and digital energy management tools. They can also facilitate system-wide initiatives involving the development of digital twins of energy networks and decentralised optimisation tools.

Box 4: Operationalisation of Recommendation 4 – Common data models in energy

ETIPs and IWGs should support R&I activities that promote the use of common data structures in the energy sector, including shared energy data models, to ensure semantic interoperability across several energy domains (electricity, heating, cooling, water, gas, and e-mobility). Through collaborative projects and cross-sector pilots, they should test interoperable data architectures across electricity networks, buildings, mobility and distributed energy resources. These architectures should rely on unified APIs to enable secure, standardised data exchange between platforms and stakeholders. Such efforts will improve data usability for digital energy applications and enable innovative services such as e-mobility solutions, smart building services, flexibility services, and digital energy management tools, while contributing to interoperable energy data ecosystems in Europe and facilitating system-wide initiatives to develop digital twins of energy networks and decentralised optimisation tools.

WHY

Challenges identified by TF members and literature review

Diverse players in the digital transformation of the European energy industry still employ proprietary data formats and stand-alone data models, which prevent end-to-end integration and raise integration costs.

A lack of shared data models and interoperable protocols is a core obstacle to the digital transformation of the European energy industry, an issue confirmed across all technologies.[69]

Without interoperable data structures, key applications such as integrating EVs or household batteries into grid management, rolling out digital twins, or supporting real-time balancing via demand response are not feasible.

Further barriers include vendor lock-in, heterogeneous national regulatory schemes, and a cultural reluctance to share energy data. A Common Data Model (CDM) for the energy sector can remove the interoperability barriers, facilitate systems' integration, and favour the digitalisation of the European energy industry.

69 European Commission — Energy. Strategic Energy Technology Plan (SET Plan) — official portal. Link: https://energy.ec.europa.eu/topics/research-and-technology/strategic-energy-technology-plan_en

Expected outcomes and contribution to EU priorities

Sharing a common model of energy data will drive the development of an integrated system of interlinked systems in Europe. Distributed resources such as EVs, residential batteries, and industrial flexibility will be enabled to participate in real-time balancing services, contributing to system resilience and flexibility. It addresses the European Union's energy security and integration of clean energy transition goals.

Consumer empowerment is a central pillar of the Clean Energy Package and the European Green Deal.[70] CDMs enable prosumers to grant third-party apps access to their usage data without friction. This fosters competition and transparency in energy services. Metrics like the Smart Readiness Indicator for buildings will benefit from standardised underlying data, enabling accurate benchmarking and enhanced digital capability across the building stock.[71]

Furthermore, this recommendation aligns with the EU's large-scale initiatives. ENTSO-E's (the European Network of Transmission System Operators for Electricity) 2024 mandate position emphasises sovereignty, interoperability, and secure data sharing.[72] A CDM for energy is being envisioned for 2030 as the semantic foundation of the European Energy Data Space, harmoniously encompassing energy data within Europe's broader digital world.[73]

WHAT

The development and implementation of a robust CDM for Energy that covers all major energy domains will be based on existing standards to ensure coherence across electricity, heating, cooling, gas, water, electromobility, and flexible resources. This CDM is the essential semantic layer for the European Energy Data Space. It is the only way to ensure that data shared under the Data Act is meaningful and usable across different systems and Member States. The CDM for the European electricity sector will be based on the well-established IEC CIM standards (IEC 61970/61968/62325).
At its core, it will define a common data ontology that covers the semantic meaning of variables such as power usage, state of charge, voltage, flexibility status, and tariff information. Such an ontology should cover all SET Plan technologies.

It will specify unified application programming interfaces to enable secure retrieval and transmission of energy information. This model must link device-level data flows, communication protocols, and business use cases into one coherent structure, adhering to the principles of the Smart Grid Architecture Model (SGAM), which segments interoperability into component, communication, information, function, and business layers.[74]

It will extend the CIM to cover emerging domains critical to sector coupling fully. Key priorities for extension include:

- E-Mobility: Standardising data models for charging sessions, battery status, and V2G flexibility.
- Buildings: Harmonising data from Building Management Systems, heat pumps, and thermal storage.
- Flexibility Services: Creating a common language for defining, procuring, and settling flexibility products.
- Challenge of Governance: The main challenge is not technical but establishing a clear and agile governance process for managing and updating the CDM to keep pace with rapid technological evolution.

This initiative aims to release a publicly available CDM specification that outlines data schemas in machine-readable formats, along with sample API endpoints and test datasets. Pilot implementations should demonstrate seamless interoperability among meters, asset controls, building management systems, electromobility services, and grid monitoring platforms.[75] Ultimately, the model would facilitate system-wide initiatives like digital twins of energy networks and decentralised optimisation tools.

70 European Commission. The European Green Deal — Communication COM(2019) 640 final. Link: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52019DC0640
71 European Commission — EUR-Lex. Commission Delegated Regulation (EU) 2020/2155 and Commission Implementing Regulation (EU) 2020/2156 on the Smart Readiness Indicator (SRI) for buildings. Links: https://eur-lex.europa.eu/eli/reg_del/2020/2155/oj
72 European Commission — EUR-Lex. Commission Delegated Regulation (EU) 2020/2155 and Commission Implementing Regulation (EU) 2020/2156 on the Smart Readiness Indicator (SRI) for buildings. Links: https://eur-lex.europa.eu/eli/reg_del/2020/2155/oj and https://eur-lex.europa.eu/eli/reg_impl/2020/2156/oj
73 European Commission — Energy. Common European Energy Data Space (CEEDS) — Factsheet page. Link: https://energy.ec.europa.eu/publications/common-european-energy-data-space_en
74 CEN-CENELEC-ETSI Smart Grid Coordination Group. SGAM Usage and Examples — SGAM User Manual. Link: https://www.cencenelec.eu/media/CEN-CENELEC/AreasOfWork/CEN-CENELEC_Topics/Smart%20Grids%20and%20Meters/Smart%20Grids/4_sgcg_methodology_sgamusermanual.pdf
75 International Electrotechnical Commission (IEC). IEC 61968-9:2024 — Enterprise business function interfaces for utility operations — Part 9: Interfaces for meter reading and control. Link: https://webstore.iec.ch/en/publication/75041

WHO

The SET Plan should drive the implementation through a formal, collaborative structure with clear roles.

1. **Establish a European CDM Task Force:** The SET Plan should mandate the creation of a dedicated Task Force. This must be a joint effort between the European Commission, standardisation bodies (CEN/CENELEC), ETIP SNET, ETSI (Telecommunications Standards Institute), European institutions, ETIPs/IWGs and the legally mandated bodies for TSOs and DSOs (ENTSO-E and the EU DSO Entity). These stakeholders would include national regulatory authorities, harmonised with the Agency for the Cooperation of Energy Regulators; transmission and distribution system operators; energy service providers; meter manufacturers; IT solution vendors; and research centres.
2. **Define Clear Roles:**
   - ENTSO-E and EU DSO Entity should lead the development of the core grid-related parts of the CDM.
   - ETIP SNET should contribute R&I inputs to support the extension of the CDM to cross-sectoral domains (e-mobility, buildings, etc.), bringing in the relevant stakeholders from those sectors. It should prepare the R&I Agenda for the CDM, focusing on testing and validating extensions through pilot projects and demonstration activities, while recognising that the formal standardisation process falls within the competence of CEN/CENELEC and relevant standardisation bodies.
   - CEN/CENELEC should be responsible for the formal standardisation process.
   - IWG could support the validation of the safety-related aspects of these CDMs and contribute by defining the critical safety parameters and data fields that must be included in the CDM. It can help establish a certification process for digital twin models to ensure they accurately represent the physical plant and its safety systems, thereby supporting advanced safety analysis and predictive maintenance applications.
3. **Support Adoption:** The SET Plan should recommend that the resulting CDM be considered for reference in relevant Network Codes and EU legislation. Within its own remit, the SET Plan should encourage the use of the CDM in R&I projects receiving EU funding and promote its voluntary adoption across IWGs and ETIPs.

Task Force members and ETIPs/IWGs would establish an open working method to design, pilot, and refine the CDM openly, testing it in several Member States. Research institutions would support R&I into advanced features, pilot deployments, and compliance testing frameworks. Consumer groups would collaborate on API usability, data privacy, and information/access provisions.

The SET Plan could launch a dedicated "Digital Asset Lifecycle" and "Digital Twin for Critical Infrastructure" initiative to coordinate CDM development. This would involve funding for collaborative projects between operators and research institutions to build standardised digital twin models, including a standardised ontology and a data dictionary. The output would be an open-source data model that all stakeholders can adopt.

HOW

Implementation will follow a multi-stage methodology. The first step is to create a Europe-wide Task Force under the SET Plan, combining expertise from standardisation platforms, operators, industry, academia, and regulators. Technical development will be driven by use cases, such as system balancing using EV flexibility and cross-border digital twins, to narrow design requirements. Ontology engineers will then integrate CIM[76], OpenADR[77], OPC Unified Architecture, and downstream digital standards using semantic web languages to assemble a machine-readable CDM framework. Communication interfaces, such as MQTT[78], NGSI-LD[79], RESTful JSON APIs, and secure International Data Spaces connectors, will be aligned with CDM semantics.

76 International Electrotechnical Commission (IEC). IEC 61970-301:2020 + AMD1:2022 (CSV) — Energy management system application program interface (EMS-API) — Part 301: Common information model (CIM) base. Link: https://webstore.iec.ch/en/publication/74467

77 OpenADR Alliance. OpenADR Specifications (2.0/3.0) — official page. Link: https://www.openadr.org/specification

78 ISO/IEC. ISO/IEC 20922:2016 — Information technology — Message Queuing Telemetry Transport (MQTT) v3.1.1. (Corretto per coerenza titolo/link) Link: https://www.iso.org/standard/69466.html

79 ETSI GS CIM 009 V1.8.1 (2024-03). Context Information Management (CIM); NGSI-LD API. Link: https://www.etsi.org/deliver/etsi_gs/CIM/001_099/009/01.08.01_60/gs_cim009v010801p.pdf

Pilots and testing environments will validate the CDM in real-world settings. Examples include connecting smart buildings and charging stations with distribution networks to demonstrate demand response and flexibility markets.[80] National regulatory testing environments will facilitate innovative models such as peer-to-peer energy trading. These pilots will refine the CDM and build confidence among stakeholders.

Throughout, alignment with existing EU initiatives will be maintained to ensure technical compatibility from device interfaces to market operations.[81] Education and support materials will be disseminated, including model documentation, reference adapters, and practical workshops. Success stories will be shared to build a collaborative culture.

A CDM should not only serve systems and markets but also enable user empowerment. By embedding consumer-readable semantics, the CDM can power intuitive interfaces for energy dashboards and data-sharing consents. Prosumers, aggregators, and community energy initiatives should be able to easily plug into standardised data flows and benefit from access to aggregated analytics and optimisation tools.

The CDMs should be managed by a non-profit, vendor-neutral consortium, with a clear versioning and update process. The governance model must include a steering committee with representatives from regulators, operators, and technology developers to ensure that updates are relevant and do not compromise safety.

A model based on the principles of modern software development can be adopted:

1. A Federated Governance Structure: A central steering committee, comprising the key actors (Commission, ENTSO-E, EU DSO Entity, ETIP SNET), should oversee the core CDM. However, the detailed work on domain-specific extensions (e.g., for hydrogen) should be delegated to dedicated expert sub-groups.
2. An Open and Transparent Process: The entire governance process must be open. Any stakeholder should be able to propose a change or a new feature through a public platform. All discussions, decisions, and technical documents must be publicly accessible to ensure transparency and community buy-in.
3. Regular, Iterative Release Cycles: The CDM should be managed with a clear versioning system and a predictable release cycle (e.g., a new version every 12-18 months). This allows the model to evolve in an agile way to incorporate new technologies and market needs, rather than being locked into a multi-year standardisation process.
4. A Formal Conformance Testing Framework: To ensure the standard is implemented correctly, there must be a formal conformance testing and certification process. This will allow technology providers to certify their products as "CDM-compliant," giving buyers confidence and ensuring true interoperability.

WHEN

Short term (2026-2027) to medium term (2027-2030)

- **2026:** Integrate activities on the development of the CDM in the R&I activities of the IWG Thematic Visions, IICs and ETIP Strategic Research and Innovation Agendas to support the development of the CDM, focusing on core domains like electricity networks, metering, and charging infrastructure.
- **2026-2027:** Collaboration with Member States on the development of CDM, also including regulatory experimentation.
- **By 2030:** Deploy key projects focusing on the developed CDM and its applications (i.e. digital twins and AI systems).

KEY PERFORMANCE INDICATORS (KPIS)

Proposed KPIs to monitor implementation include:

- The percentage of Member States embedding the model into grid codes and consumer regulations;
- The adoption of the CDM in cross-domain digital initiatives such as building-energy-management platforms and electric vehicle ecosystems;
- Additional indicators include market responses, such as the number of interoperable third-party services launched and reductions in transaction turnaround times for data provisioning.

80 International Electrotechnical Commission (IEC). IEC 61968-9:2024 — Enterprise business function interfaces for utility operations — Part 9: Interfaces for meter reading and control. Link: https://webstore.iec.ch/en/publication/75041

81 European Union. Regulation (EU) 2023/2854 (Data Act) of 13 December 2023 on harmonised rules on fair access to and use of data. Official Journal of the European Union. Link: https://eur-lex.europa.eu/eli/reg/2023/2854/oj

RECOMMENDATION 5: EXPAND EUROPEAN DATA HUBS TO HOST ENERGY-RELATED DATASETS

Recommendation summary:

Energy data across Europe remains siloed within national systems, hampered by poor interoperability, cybersecurity risks, data quality issues and dependence on non-European cloud infrastructure, undermining data sovereignty and cross-border cooperation.

This recommendation supports initiatives aimed at expanding European data hubs to host energy-related datasets. This includes the adoption of a Hub-of-Hubs architecture with standardised APIs to interconnect national and sectoral data hubs through a common framework. This approach should align with and contribute to the development of European energy data spaces, enabling the structured, interoperable integration of energy data at the EU level.

IWGs, ETIPs, EERA, and CETP are recommended to set up R&I activities and pilot projects that can help identify relevant datasets and demonstrate how interconnected data platforms improve data accessibility and usability. They can also promote collaboration and knowledge sharing to support greater renewable energy integration, the development of positive energy districts and advanced energy system management. .

Box 5: Operationalisation of Recommendation 5 – European energy data hubs

ETIPs and IWGs should support initiatives aimed at expanding European data hubs to host energy-related datasets. This should include the adoption of a Hub-of-Hubs architecture with standardised APIs to interconnect national and sectoral data hubs through a common framework. This approach should also be aligned with and contribute to the development of European energy data spaces, enabling a structured and interoperable integration of energy data at the EU level. Through R&I activities and pilot projects, they can help identify relevant datasets and demonstrate how interconnected data platforms can improve data accessibility and usability. The Hub-of-Hubs architecture can serve as a foundational mechanism to feed and operationalise European energy data spaces in a consistent and scalable manner. These initiatives should encourage collaboration between research organisations, system operators, industry stakeholders and technology providers. Experimentation and knowledge sharing around interconnected data hubs should be promoted to help address challenges related to siloed data and limited interoperability, while enabling data-driven solutions that support greater renewable energy integration, the development of positive energy districts, and advanced energy system management.

WHY

Challenges identified by TF members and literature review

The deployment of SET Plan technologies can lead to:

- **Traditional siloed approaches**, where data ownership and access are strictly guarded, limiting cross-border cooperation and cross-sectoral integration[82,83]. Furthermore, national protectionist policies restrict the seamless flow of data and impede the development of a unified European energy data space. To address this, the focus should shift from isolated national data infrastructures to a federated network of interoperable national and regional data hubs, enabling secure, trusted cross-border information exchange. Moreover, this barrier is directly addressed by the *Digitalising the Energy System - EU Action Plan*[84], which promotes the creation of a European energy data space to overcome fragmented data silos and facilitate cross-border data sharing.
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82 Abraham, R., Schneider, J., Vom Brocke, J. (2019). Data governance: A conceptual framework, structured review, and research agenda. International Journal of Information Management, 49, pp. 424-438.

83 J. L. Hernández, S. Martín, V. Marinakis and I. de Miguel, "From silos to open, federated and enriched Data Lakes for smart building data management," 2023 IEEE International Workshop on Metrology for Living Environment (MetroLivEnv), Milano, Italy, 2023, pp. 29-33, doi: 10.1109/MetroLivEnv56897.2023.10164046.

84 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52022DC0552

- **Lack of interoperable solutions to enable secure and efficient data exchange**. The absence of robust and harmonised frameworks discourages actors from sharing their datasets, as they fear misuse or competitive disadvantages. The need for harmonised standards and interoperability is also underlined in the *Electricity Market Design*[85] rules and the *Energy Performance of Buildings Directive (2024)*[86], both of which encourage standardisation and interoperability to ensure seamless data exchange and enable advanced digital services.
- **Data quality**. Variability in data quality and missing metadata often prevent reliable data re-use. Producers should include clear quality descriptions and provenance information to increase confidence and usability.
- **Cybersecurity risks and the need to ensure data integrity** present technical and operational hurdles, particularly when integrating new digital solutions with existing legacy systems.
- **Misunderstanding of privacy regulations, such as GDPR, creates** additional hesitancy among stakeholders to share data.
- **Dependence on non-European cloud infrastructure** undermines data sovereignty and trust. Strengthening EU-based, GAIA-X-aligned infrastructure is essential to ensure a secure and sovereign backbone for the future European Data Space. This challenge is linked to the *EU Data Act*[87] and the *Data Governance Act*[88], which aim to strengthen European data sovereignty and reduce dependency on non-European cloud providers by creating safe, trustworthy, and accessible European data spaces.

Addressing these challenges requires a coordinated effort to establish secure, interoperable, and trusted European data hubs dedicated to energy datasets. Such hubs are instrumental in overcoming fragmentation, supporting innovation, and fostering data-driven services critical to achieving decarbonisation and digitalisation goals.

Expected outcomes and contribution to EU priorities

The recommendation focuses on expanding European data hubs, directly advancing the EU's objectives on digital sovereignty, climate neutrality, and energy system integration. By increasing safe and accessible cloud storage within Europe, this recommendation will enhance data availability, facilitate cross-border energy cooperation, and underpin advanced digital services, such as AI-driven optimisation and digital twins. It will also promote data quality assurance, standardised metadata, and transparency, thus ensuring that shared information is trustworthy and technically usable.

Expected impact:

- **Contribution to the EU's Digital Decade targets, the Green Deal, and the Energy Union strategy** by enabling better use of data for climate action[89] and innovation. The recommendation supports a federated "hub-of-hubs" model that connects existing national and thematic data hubs through common trust, security, and interoperability services. This model forms the backbone of the European Energy Data Space, consistent with the Data Act, NIS2 Directive, and GAIA-X principles.
- **Accelerated deployment** of renewable energy systems, enhanced grid management, and improved energy efficiency through data-informed decisions. The recommendation also aligns with the Digital Europe Programme and Horizon Europe, which support research and innovation activities, including AI and high-performance computing infrastructure, which are essential for advanced energy data analysis and system optimisation.
- **Promotion of coherence among Member States** in the context of the SET Plan, reducing market fragmentation, and creating a resilient, flexible energy system capable of meeting 2030 and 2050 climate targets.
- **Prioritisation of European-controlled infrastructures**, able to mitigate dependency risks and strengthen competitiveness in global digital and energy markets, ultimately driving societal and economic benefits across Member States.

85 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202401711
86 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202401275
87 https://eur-lex.europa.eu/eli/reg/2023/2854/oj
88 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32022R0868
89 Stamatopoulos E., Forouli A., Stoian D., Kouloukakis P., Sarmas E., Marinakis V. (2024). An adaptive framework for assessing climate resilience in buildings. Building and Environment 264, 111869.

WHAT

The proposed recommendation entails establishing and scaling up European-level data hubs dedicated to energy datasets. Rather than a single centralised hub, the approach should prioritise the federation and interconnection of existing national hubs, ensuring seamless data exchange through shared standards, APIs, and governance frameworks.

Potential solutions include:

1. **Federation of National Hubs:** Expanding and connecting existing national and regional data hubs (e.g. national smart meters data hubs, TSO/DSO platforms) through a common interoperable and trustworthy framework. This federated approach will be designed to create European data hubs that are more resilient and scalable, while respecting national governance.

2. **Development of a "Hub-of-Hubs" Architecture**, offering interoperable and standardised data models and APIs to facilitate seamless data exchange among existing national and European data hubs. The European level of this architecture must provide core services that enable standard, secure, and seamless interoperability mechanisms, implementing advanced cybersecurity and data governance frameworks tailored to the energy sector's needs.

3. **Incorporate a European catalogue of energy data hubs and datasets**, as a master data catalogue to provide a common identity for data discovery, identification, use and reuse while avoiding duplication of storage.

4. **Incentivise data sharing through regulatory and financial mechanisms**, such as tax benefits or access to competitive funding calls.

Moreover, solutions should include the creation of shared service layers enabling anonymisation, aggregation, and secure access controls to foster trust among data providers and users.

A harmonised approach to metadata standards and prioritisation frameworks (e.g., defining critical versus non-critical data (see recommendation 6)) will be essential to streamline integration and promote reusability across national and regional contexts. Leveraging the Data Act and recent advances in energy data spaces initiatives will be critical to operationalise these solutions efficiently.

WHO

The recommendation could apply to:

- **All ETIPs/IWGs of the SET Plan** are responsible for integrating the recommendation into their Thematic Visions, IICs and SRIAs, particularly in domains such as energy systems integration, positive energy districts, and renewable and net zero technologies.
- **EU and national governments and ministries** are encouraged to harmonise policies to support common data hub infrastructure, ensure regulatory coherence, and align national digital and energy transition strategies. Member States should ensure that existing data hubs (e.g., smart meters or grid data platforms) adhere to the common interoperability and trust framework and participate in the federated network.
- **Industry actors** (utilities, technology providers, DSOs/TSOs, energy communities) are expected to provide data, adopt common standards, and co-develop interoperable solutions.
- **Financial institutions and investors**, to support the development of infrastructures through funding instruments and green financing schemes, for example.

Special emphasis should be placed on fostering coherence among Member States around shared goals, such as climate action and competitiveness, by enabling cross-border data flows and supporting innovation ecosystems.

HOW

The SET Plan should implement this by catalysing the creation of the necessary infrastructure through a combination of strategic funding and coordination. Actions that can be taken by the IWGs and ETIPs include:

- **National and EU-level funding programmes** (e.g., Horizon Europe, Connecting Europe Facility) should prioritise projects that contribute to the development of European energy data hubs. Best practices include the GAIA-X[90] initiative and existing national data spaces (e.g., Germany's energy data space[91]), which provide blueprints for secure, federated data sharing.
- This funding can be used to **build the "Federation layer" of the Hub-of-Hubs architecture**, composed of software, standards and certification mechanisms that link national hubs and guarantee interoperability, data quality and security.
- **Support National Hub Development** by encouraging Member States to use national funding and Recovery and Resilience Facility (RRF) funds to establish or upgrade their national energy data hubs, ensuring they are built in compliance with the common European reference architecture.
- **Coordinate through a Multi-Stakeholder Body**. The implementation should be overseen by a multi-stakeholder body convened under the SET Plan, comprising the European Commission, ETIP SNET, ENTSO-E, the EU DSO Entity, and representatives from national data hub initiatives.
- **Pilot projects** co-led by industry and academia should demonstrate the interoperable data sharing "Hub-of-Hubs" architecture and generate evidence on technical and economic viability. These projects could be hosted on a European cloud infrastructure like Gaia-X.
- **State-of-the-Art Security by Design**. The hubs must implement the highest level of security by design, including end-to-end encryption, robust identity management, and continuous security monitoring.
- **A robust Certification Scheme**. A mandatory, EU-wide certification scheme is essential. Data hubs must be independently audited and certified against a clear set of criteria covering cybersecurity (based on NIS2), data protection (GDPR), and interoperability (based on the common reference architecture). This provides a clear "stamp of approval" that builds trust.
- **Transparent and Independent Governance**. The governance of the data hubs and the overarching data space must be transparent and managed by a neutral, not-for-profit entity. The rules for participation, data access, and pricing must be public and non-discriminatory.
- **EU-based Cloud and Data Sovereignty**. To ensure digital sovereignty and build trust, there must be a clear preference for, and ultimately a move towards, hosting critical energy data on EU-based, GAIA-X-compliant cloud and edge infrastructures. This mitigates risks associated with the jurisdiction of non-EU cloud providers.
- **Capacity-building initiatives**, including training on digital skills and data governance, will address gaps in digital literacy, particularly in public administrations and SMEs.
- **Continuous stakeholder engagement** and feedback loops will be essential to refine solutions and achieve broad adoption.

90 Home - Gaia-X: A Federated Secure Data Infrastructure
91 https://www.energydata-x.eu/en/

WHEN

A potential timeline for implementing the action points could include:

- **Short-term** (2026-2027): Develop the Federation layer (interoperability and metadata standards) and launch initial pilot projects, begin drafting regulatory adjustments. Start the first European catalogue pilot interconnecting a limited number of national energy hubs.
- **Medium-term** (2027-2030): Scale successful pilots, establish cross-border data hubs, harmonise national policies, and promote widespread adoption through incentives and capacity-building. Deploy the Federation layer and trust services connecting national infrastructures.
- **Long-term** (post-2030): Full integration of energy data hubs into the European energy system, supported by continuous upgrades, new technological advances (e.g., AI-driven analytics), and strengthened governance frameworks. Ensure long-term maintenance of the European Data Catalogue as a central discovery and coordination mechanism.

KEY PERFORMANCE INDICATORS (KPIS)

Proposed KPIs to monitor implementation include:

- Integration milestones: Number of ETIPs/IWGs integrating data hub concepts into their Thematic Visions, IICs and SRIAs.
- Infrastructure growth: Volume of energy data securely stored and exchanged via European data hubs (measured in petabytes/year).
- Stakeholder participation: Number of participating industry actors, research organisations, and Member States adopting the shared infrastructure.
- Policy alignment: Number of national policies harmonised to support cross-border data sharing and cloud infrastructures.
- Technological maturity: Advancement of data-related solutions measured by increases in Technology Readiness Levels (TRLs) and Societal Readiness Levels (SRLs).
- Impact on SET Plan objectives: Evidence of enhanced energy system flexibility, increased RES integration, and improved energy efficiency facilitated by data use.

RECOMMENDATION 6: DEVELOP A DATA PRIORITISATION FRAMEWORK FOR THE SET PLAN

Recommendation summary:

The rapid proliferation of Internet of Things (IoT) networks and smart devices generates massive volumes of energy data, yet much remains unshared or indiscriminately shared, risking communication network overload while leaving high-value datasets underutilised for innovation and system optimisation.

This recommendation supports the development of a data prioritisation framework to identify and prioritise key datasets for sharing within the SET Plan ecosystem. This should include methodologies for classifying and ranking data by relevance and impact, ensuring that data-sharing efforts focus on high-value datasets relevant to renewable integration and energy system optimisation.

IWGs, ETIPs, EERA, and CETP are recommended to set up R&I activities and stakeholder engagement that promotes the use of AI-driven dynamic prioritisation approaches and define domain-specific use cases where relevant datasets are identified, analysed and prioritised. This will promote efficient and impactful data-sharing practices and help avoid unnecessary data flows that could overload communication networks or data storage systems.

Box 6: Operationalisation of Recommendation 6 – Data prioritisation framework

ETIPs and IWGs should support the development of a data prioritisation framework to identify and prioritise key datasets for sharing within the SET Plan ecosystem. This should include methodologies for classifying and ranking data by relevance and impact, ensuring that data-sharing efforts focus on high-value datasets relevant to renewable integration and energy system optimisation. Through collaborative R&I activities and stakeholder engagement, ETIPs and IWGs should promote the use of AI-driven dynamic prioritisation approaches and advanced analytics to adapt data-sharing priorities to evolving energy system needs. By testing and refining these methodologies through pilots and research activities, and by defining and implementing domain-specific Use Cases where relevant datasets are identified, analysed and prioritised, they can promote efficient and impactful data-sharing practices. Such Use Cases should reflect the specific needs of each technology domain and support decision-making processes. This will help avoid unnecessary data flows that could overload communication networks or data storage systems within the SET Plan community.

WHY

Challenges identified by TF members and literature review

The deployment of SET Plan technologies can lead to:

- **Underutilised massive volumes of data**. The rapid proliferation of IoT networks, advanced metering infrastructure, and smart devices has generated massive volumes of data in the energy sector. Despite this abundance, much of the data remains unshared and underutilised[92]. Energy data owners, including utilities, building managers, and industrial operators, often lack clarity on which data should be prioritised for sharing, leading to either data hoarding or indiscriminate sharing. The challenge, therefore, is to share only the necessary data, in line with the application context and the problem to be solved. This challenge is addressed by the *Digitalising the Energy System - EU Action Plan*[93], which promotes the creation of a European Energy Data Space to enable better data sharing practices and support the identification and governance of critical datasets.

92 J. L. Hernández, S. Martín, P. Kapsalis, K. Katsigarakis, E. Sarmas and V. Marinakis, "Building a Data Lake for Smart Building Data: Architecture for Data Quality and Interoperability," 2023 14th International Conference on Information, Intelligence, Systems & Applications (IISA), Volos, Greece, 2023, pp. 1-8, doi: 10.1109/IISA59645.2023.10345892.

93 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52022DC0552

- **Overload of communication networks and storage**. On the contrary, indiscriminately sharing all generated data can overload communication networks, impose excessive storage demands, and increase cybersecurity and privacy risks. These concerns are also highlighted in the *Energy Efficiency Directive (2023)*[94] and the *Energy Performance of Buildings Directive (2024)*[95], which promote smart data management to optimise energy use while ensuring security and privacy by design. Moreover, the cost and energy intensity associated with storing and transmitting vast quantities of non-prioritised data contradict sustainability and efficiency objectives.
- **Lack of identification of truly valuable data**. Only a fraction of the data generated is truly valuable for optimising energy efficiency, advancing system integration, or supporting policy and market innovations. Without a clear prioritisation framework, stakeholders cannot make informed decisions about data governance, leading to missed opportunities for innovation and operational improvement.
- **Economic value of data** ("data economy") is not being fully realised, as unprioritised data flows dilute potential revenue streams and hinder the development of value-added data services. The *EU Data Act*[96] and the *Data Governance Act*[97] further underline the need to create value from data, incentivise its reuse, and establish clear rules for data access and prioritisation across the energy sector.

Addressing these challenges requires establishing a coherent framework to identify, categorise, and prioritise key data types, ensuring that the most impactful and actionable data is shared to maximise benefits for the energy transition and digitalisation efforts.

Expected outcomes and contribution to EU priorities

Developing a data prioritisation framework that will facilitate the efficient, secure, and impactful use of energy-related data, directly supporting EU objectives on digitalisation, sustainability, and energy system integration. By focusing on high-value data, this framework will reduce the unnecessary burden on communication networks and storage infrastructure, thereby enhancing cybersecurity and optimising resource utilisation.

Expected impact:

- Alignment with the EU's Green Deal targets by **supporting more precise energy efficiency measures** and enabling advanced analytics and AI applications that can drive decarbonisation.
- Contribution to the goals outlined in the Digital Decade strategy, particularly in **strengthening data governance and fostering the data economy.**
- Reinforcement of the objectives of the Energy Union and the SET Plan by enabling **more informed policy and market interventions**, improving demand-response schemes, and facilitating sector coupling.
- For the SET Plan, the recommendation will **enhance coherence across Member States and stakeholder groups,** supporting harmonised data-sharing practices that accelerate innovation and market uptake of new technologies. Initiatives such as Horizon Europe, the Digital Europe Programme, and the Clean Energy Transition Partnership provide concrete frameworks and funding mechanisms to facilitate data-driven innovation and prioritisation in energy systems.
- A well-implemented prioritisation framework will **empower stakeholders to unlock the true value of their data assets**, stimulate cross-sectoral collaboration, and build a resilient, intelligent, and flexible energy system capable of achieving the EU's 2030 and 2050 climate and digitalisation goals.

94 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023L1791
95 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202401275
96 https://eur-lex.europa.eu/eli/reg/2023/2854/oj
97 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32022R0868

WHAT

This recommendation proposes the design and implementation of a comprehensive data prioritisation framework tailored to the energy sector. The potential solution includes:

1. Developing methodologies to classify and rank data types based on their relevance and potential impact on energy efficiency, system optimisation, and market innovation.
2. Integrating AI and advanced analytics to create the prioritisation framework by supporting real-time assessment and dynamic prioritisation of data, always in line with the AI Act.
3. Safeguarding AI application against bias by: (i) Human-in-the-loop governance, making the final decision on the rules of the prioritisation framework; (ii) Mandate of Explainable AI (xAI), guaranteeing that all the models are explainable; (iii) Regular bias audits and models trained on representative datasets.
4. Avoiding over-complexity by defining specific, well-defined use cases before being scaled up. This will allow for an iterative, incremental, and manageable approach.
5. Validating and verifying the AI models of the prioritisation framework by an independent body.
6. Establishing clear guidelines and decision trees for data owners on what data should be shared, when, and under what conditions.
7. Embedding data economy considerations to encourage monetisation opportunities and reward data sharing.

Additionally, the proposed framework should consider technical aspects (e.g., data quality, granularity, and temporal value), regulatory requirements (e.g., GDPR and the Energy Performance of Buildings Directive), and economic incentives. By focusing on value-added data, this approach will enable stakeholders to contribute more strategically to shared energy data spaces, while maintaining compliance and protecting sensitive information. The solution should be flexible enough to adapt to evolving technologies and market needs, supporting continuous improvement and scalability across different contexts and Member States.

WHO

The recommendation applies to:

- **All ETIPs/IWGs of the SET Plan,** expected to incorporate the prioritisation framework into their SRIAs, IICs and Thematic Visions by identifying, for their respective technology domains, the high-value datasets that should be prioritised for sharing and the specific use cases where prioritised data would deliver the greatest R&I impact.
- **EU and national governments and ministries**, responsible for creating supportive policy and regulatory environments, incentivising adoption through funding schemes and compliance mechanisms.
- **Industry actors** (DSOs/TSOs, energy retailers, technology developers), tasked with operationalising the framework in daily activities, sharing prioritised data, and integrating the guidelines into business strategies.
- **Academia and research organisations**, to develop methodologies, provide validation, and assess impacts of prioritised data sharing on system performance and innovation outcomes.

Special emphasis should be placed on aligning national strategies to ensure coherent implementation across Member States, thus avoiding fragmentation and enabling a unified European approach to energy data sharing.

HOW

The implementation of this recommendation by the IWGs and ETIPs includes:

- **Multi-stakeholder co-design workshops** to define the framework's structure, criteria, and use cases. Drawing inspiration from best practices in sectors such as healthcare[98,99] and transport[100] (which already use data triage models), energy stakeholders should collaborate to establish clear classification standards.
- **Elaboration of a value-vs-Sensitivity Matrix** to classify the data types based on two axes: Value of the data to the Energy System (criticality and representativeness of the data samples) and Data Sensitivity (to determine the degree of protection required). Based on this matrix, a tiered approach to Data Sharing can be applied considering different tiers (e.g. Tier 1-high value, low sensitivity-, Tier 2-high value, high sensitivity-, Tier 3-Low value).
- The framework must be agile enough to be **updated as new use cases and technologies emerge.** To this end, AI and machine learning technologies should be piloted to assist in the continuous evaluation and reclassification of data as systems and markets evolve.
- **Support from EU programmes** (e.g., Horizon Europe, Digital Europe) will be critical to fund pilots and capacity-building initiatives where the prioritisation framework will be tested in specific use cases. This should be done in collaboration with regulatory bodies, which should guide the integration of the framework with existing and upcoming legislation, such as the Data Act and national energy data governance frameworks.
- **Awareness campaigns and training sessions** should be organised to improve digital literacy among data owners, ensuring they understand both the strategic and operational benefits of prioritisation.
- **Establishing monitoring and feedback mechanisms** will allow the framework to be refined over time, ensuring it remains responsive to technological advances and stakeholder needs.
- Once the data prioritisation framework is developed, the SET Plan should **embed it into the governance of the European Energy Data Space**. Any request for data access within the data space would be assessed against this framework.

WHEN

- **Short-term (2026-2027):** Launch of co-design activities, development of the initial prioritisation criteria, and commencement of pilot projects across selected Member States.
- **Medium-term (2027-2030):** Scaling of successful pilots, refinement of the framework based on feedback, and broad rollout supported by regulatory and financial incentives.
- **Long-term (post-2030):** Full integration of the framework into national and European data-sharing practices, supported by continuous updates and technological advancements (e.g., integration with real-time AI analytics).

KEY PERFORMANCE INDICATORS (KPIS)

- Proposed KPIs to monitor implementation include:
- Framework adoption: Number of ETIPs/IWGs and national governments incorporating the framework into strategic documents and policies.
- Stakeholder engagement: Number of industry actors and research institutions actively applying the framework.
- Data efficiency: Reduction in the volume of non-prioritised data transmitted and stored, measured as a percentage decrease compared to baseline levels.
- AI integration: Share of prioritisation processes supported by AI and advanced analytics tools.
- Market impact: Increase in monetised data-sharing agreements and value-added data services enabled by prioritisation.
- Contribution to SET Plan objectives: Measurable improvements in system flexibility, energy efficiency, and innovation outcomes directly attributable to more strategic data use.
- Impact on SET Plan objectives: Evidence of enhanced energy system flexibility, increased RES integration, and improved energy efficiency facilitated by data use.

98 https://health.ec.europa.eu/ehealth-digital-health-and-care/european-health-data-space-regulation-ehds_en
99 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52022PC0197
100 https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52020DC0789

RECOMMENDATION 7: DEVELOP A EUROPEAN ENERGY DATA SPACE ROLLOUT PLAN

Recommendation summary:

The effective digitalisation of the energy sector faces critical challenges including fragmented and inconsistent data across systems, significant implementation costs, gaps in regulatory and market frameworks, and insufficient trust and incentives for data sharing among stakeholders.

This recommendation promotes activities supporting the development of a phased rollout plan for the European Energy Data Space, considering also the recommendations from the Smart Energy Expert Group and the framework defined by the Common European Energy Data Space.

IWGs, ETIPs, EERA, and CETP are recommended to foster projects focusing on high-impact cross-sectoral and cross-border use cases, such as coordination between Transmission and Distribution System Operators, e-mobility and demand response. Through R&I projects, demonstration activities, and stakeholder collaboration, these initiatives can test data-sharing mechanisms and digital solutions across energy sectors and Member States, promoting the design, testing, and validation of advanced AI-based, data-driven services and digital twin applications to optimise energy system planning and operation.

Box 7: Operationalisation of Recommendation 7 – European energy data space rollout plan

ETIPs and IWGs should promote activities to support the development of a rollout plan for the European Energy Data Space, while also considering recommendations from the Smart Energy Expert Group and the framework defined by the Common European Energy Data Space, enabling the phased deployment of interoperable energy data infrastructures and services. This includes fostering projects that focus on high-impact cross-sectoral and cross-border use cases, such as TSO–DSO coordination, e-mobility, and demand response. Through R&I projects, demonstration activities and stakeholder collaboration, these initiatives can test data-sharing mechanisms and digital solutions across energy sectors and Member States. By supporting experimentation and coordination among stakeholders such as TSOs, DSOs, commercial actors, end users and communities, ETIPs and IWGs should promote the acceleration of interoperable data infrastructures and data-driven services for the European energy system, namely by designing, testing and validating advanced AI-based data-driven services and digital twin applications to optimise energy system planning and operation.

WHY

Challenges identified by TF members and literature review

The effective digitalisation of the energy sector is fundamentally dependent on robust data frameworks, yet it faces several critical challenges:

- Fragmented and inconsistent data across systems and infrastructure, leading to a lack of high-quality energy data from foundational elements like smart metering and advanced control infrastructure. The Blueprint for the Common European Energy Data Space (CEEDS) explicitly calls for a coordinated European framework to improve data availability and interoperability across foundational systems (e.g., meters, smart grid data), highlighting that data is often locked in by OEMs or service providers, limiting its useful pooling and reuse.
- Significant implementation costs for necessary data infrastructure upgrades, with often unclear returns on investment.
- Gaps in existing regulatory and market frameworks[101], which hinders clear definitions for data access, ownership, and monetisation. The ETIP SNET policy paper "Energy Data Space" identifies opportunities and challenges for rapid deployment, including regulatory clarity and market frameworks[102].

101 Toderean L., Cioara T., Anghel I., Sarmas E., Michalakopoulos V., Marinakis V. (2025). Demand response optimization for smart grid integrated buildings: Review of technology enablers landscape and innovation challenges. Energy and Buildings, 326, 115067.

102 https://smart-networks-energy-transition.ec.europa.eu/publications/etip-publications

- Complexities arising from large volumes of data[103] with varying quality and consistency, coupled with the need to secure sensitive information and overcome a persistent lack of interoperability between diverse data sources.
- A pervasive lack of trust and insufficient incentives for data sharing among stakeholders preventing the full realisation of a collaborative digital energy ecosystem. ENTSO-E's position paper[104] clearly states that energy data spaces must be secure, interoperable, privacy-centric, and aligned with EU values, essential for fostering trust and collaboration.

Expected outcomes and contribution to EU priorities

The expected impact and contribution to EU priorities include:

- Major contribution to the implementation of the Digitalisation of Energy Action Plan (DoEAP[105]), by nurturing the concept of Energy Data Spaces, introducing best practices for energy data-sharing, and encouraging interoperability and the development of unifying industry standards. This will foster an efficient and competitive market for emerging cyber-secure data-exchange applications and services.
- Empowering businesses and individuals as per the EU Data Act[106], by paving the way for the EU's Digital Decade through digital solutions built on a common European cloud-edge infrastructure. It will establish a harmonised framework for industrial, non-personal data pooling, processing, and sharing across the EU.
- Enhancing market participation of energy consumers[107] by providing them with greater access to and control over their energy data, facilitating their engagement in local flexibility markets and energy communities. This fosters new market opportunities and energy services tailored to consumer needs.
- Strengthening compliance with the NIS2 Directive[108] (Directive (EU) 2022/2555), driven by the integration of secure and trusted data exchange mechanisms. This directly contributes to fulfilling the stringent cybersecurity risk management and incident reporting obligations mandated by the NIS2 Directive, significantly enhancing the resilience of critical energy infrastructure systems against evolving cyber threats and bolstering the security of the energy supply.

WHAT

The SET Plan should foster R&I and deployment of a portfolio of interoperable solutions that address the core challenges of data sharing in the energy sector. It should establish a European Energy Data Space Rollout Programme as a formal, phased and use-case-driven roadmap. The rollout should:

- Start with high-impact, cross-border use cases, prioritising: (i) TSO–DSO coordination for renewable integration and congestion management; (ii) E-mobility for seamless cross-border charging and roaming; (iii) Demand response to enable industrial and commercial consumers to participate in pan-European flexibility markets.
- Focus initially on the "minimum viable ecosystem", i.e., the Common Data Model (CDM), trust framework, and reference architecture, ensuring early national data hubs are interoperable.
- Adopt a federated model with strong national alignment mechanisms, ensuring Member State initiatives evolve coherently.

Concrete building blocks include:

- **Establishing a comprehensive Reference Architecture for a European Energy Data Space** (e.g. in the EnerShare EU project) aligned with recognised frameworks such as the International Data Spaces Reference Architecture Model[109] and GAIA-X[110] principles to enable seamless integration of various data sources.
- **An open, standardisable and Energy Data Space compliant interoperability and trust infrastructure** for the adaptation and upscale of data-driven trustworthy AI-powered services and Apps (e.g. in EnerTEF EU project). This requires the development and deployment of interoperability building blocks, including standardised interfaces and

103 Marinakis et al. (2020). From big data to smart energy services: An application for intelligent energy management. Future Generation Computer Systems 110, 572-586.
104 https://www.entsoe.eu/2024/11/06/data-spaces-in-the-energy-sector-enabling-the-green-energy-transition/
105 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022DC0552&qid=1666369684560
106 https://eur-lex.europa.eu/eli/reg/2023/2854/oj/eng
107 https://energy.ec.europa.eu/topics/markets-and-consumers/energy-consumers-and-prosumers/protecting-and-empowering-energy-consumers_en
108 https://eur-lex.europa.eu/eli/dir/2022/2555/oj/eng
109 https://internationaldataspaces.org/wp-content/uploads/dlm_uploads/IDSA-Position-Paper-GAIA-X-and-IDS.pdf
110 https://gaia-x.eu/

open APIs that leverage widely accepted energy-related ontologies (such as SAREF), to facilitate cross-energy and cross-sector data exchange (e.g., the HEDGE IoT EU project).

- **Establishing dynamic data and service marketplaces**, incorporating blockchain/smart contract-enriched platforms for transparent data exchange, value creation, and fair compensation, driving participation from diverse energy stakeholders and consumers.
- **A framework for Trust and Sovereignty**: Implement technical building blocks that give data owners full control. This includes federated identity management (secure digital IDs), robust data-use controls, and technologies such as DLT/Blockchain to ensure transparent, tamper-proof data transactions.
- **Designing and validating advanced AI-based data-driven services and Digital Twin applications**, particularly those leveraging privacy-preserving federated learning[111], to offer cross-value chain insights and optimise energy system planning and operation. This may cover specific energy use cases, such as renewable energy valleys (e.g., the Crete Valley EU project), energy communities (e.g., the ENPOWER & PVSmile EU projects), residential energy carrier-agnostic demand response (e.g., the DEDALUS EU project), and buildings' decarbonisation and electrification (e.g., the META BUILD EU project).
- **Aligning with and contributing to EU-level data space initiatives and standardisation bodies**, ensuring that the developed frameworks and solutions are scalable, replicable, and contribute to a level playing field for data sharing across Europe.

WHO

Broadly applicable to all SET Plan ETIPs and IWGs, which are responsible for integrating data space concepts and R&I activities into their respective Thematic Visions, IICs, and SRIAs. The successful creation of a European Energy Data Space requires the active participation of a wide range of stakeholders across the entire data and energy value chains, including the following key groups:

- **Energy System Operators (TSOs and DSOs) and infrastructure managers:** This includes TSOs, DSOs, and multi-vector operators, including gas, district heating and geothermal infrastructure managers. They are essential data providers and the primary users of data-driven services to improve grid planning, operations, and resilience.
- **Commercial Energy Actors:** This group includes energy retailers, suppliers, aggregators, and ESCOs. The data space provides them with the opportunity to develop new business models and offer innovative, data-driven services to their customers.
- **Technology and Data Service Providers:** This includes RES technology manufacturers, ICT companies, data service and App developers, data brokers, and data space operators. They are responsible for building the technical components of the data space and creating the value-added services that run on it
- **End Users and Communities:** As both data generators and beneficiaries, individuals and communities are key to ensuring the data space responds to societal needs. Their engagement is critical for data provision, co-creation of new services, and ensuring the equitable distribution of benefits. This includes promoting data cooperatives as decentralised enablers.
- **Public Authorities and Regulators:** This includes EU institutions, national ministries, and local authorities (e.g., municipalities). They are responsible for creating a supportive and harmonised regulatory framework, monitoring compliance (e.g., with GDPR), and providing real-life knowledge to inform the development of new regulations.
- **Academia and Research Organisations:** These are the institutions that drive the underlying scientific and technological advancements. Their research, particularly in areas such as privacy-preserving federated learning and new data governance models, directly informs the long-term SRIAs and ensures that the data space is built on cutting-edge, trustworthy technology.

111 Michalakopoulos V., Sarantinopoulos E., Sarmas E., Marinakis V. (2024). Empowering federated learning techniques for privacy-preserving PV forecasting. Energy Reports 12, 2244-2256.

- **R&D Sector (RTOs and National/European Labs):** Public research and technology organisations, national labs, and EU bodies (e.g. JRC) that operate testbeds, living labs and standards/pilots environments. They bridge fundamental research and market deployment, validating interoperability and security at scale and contributing to reference architectures, open-source building blocks, and conformity assessment schemes.
- **Financial Institutions:** Investors and financial bodies are needed to support the development and deployment of the required data infrastructure through green financing and other investment instruments.

HOW

The SET Plan should support and contribute to the governance and strategic steering of the rollout of the European Energy Data Space, in coordination with the Smart Energy Expert Group (SEEG) and the framework of the Common European Energy Data Space (CEEDS):

- Create a dedicated European Energy Data Space Rollout Programme under the SET Plan, with a Programme Board comprising the European Commission (DG ENER/DG CNECT), ACER, ENTSO-E, the EU DSO Entity, and ETIP SNET. This body will oversee coordination and ensure national initiatives remain coherent and interoperable.
- The Programme Board should publish a transparent roadmap with concrete milestones, deliverables, and KPIs for each rollout phase (e.g., by Q4 2026: finalisation of the Common Data Model for E-Mobility; by Q2 2027: first cross-border pilot operational).
- The SET Plan must ensure coherence between funding streams (Digital Europe, CEF, Horizon Europe, and national programmes), strategically aligning them to support the different rollout phases — from foundational R&I to scaled deployment and full integration.

Indicative actions that can be taken by the IWGs and ETIPs include:

- **Integrating R&I activities on energy data spaces into Thematic Visions and IICs (for IWGs), and Strategic Research and Innovation Agendas (for ETIPs):** This involves developing and applying standardised semantic data models (ontologies) to ensure cross-domain and cross-sector data interoperability. These plans should also incorporate the design and validation of AI/ML tools at the edge and in the cloud.
- **Developing and deploying common, secure, and interoperable data exchange platforms and services:** This includes fostering the creation of IDS-compliant connectors and middleware to orchestrate data exchange, ensuring data trust, sovereignty, and control. Examples include implementing federated identity and access management frameworks and usage control technologies for data enforcement, compliant with privacy regulations.
- **Establishing and leveraging transparent data and service marketplaces:** This action promotes the development of AppStore-like marketplaces enriched with blockchain/smart contracts for data sharing, value creation, and heterogeneous compensation mechanisms. These platforms can host AI-based services and digital twin applications for energy system optimisation.
- **Intensifying collaboration and synchronisation with broader EU-level initiatives and standardisation bodies:** This means actively engaging with groups like GAIA-X, IDSA, and BRIDGE[112], and contributing to relevant SDOs (e.g., ETSI SmartM2M, IEC TC57, ISO/IEC JTC1) to drive the evolution and adoption of common standards and reference architectures for energy data.

112 https://bridge-smart-grid-storage-systems-digital-projects.ec.europa.eu/

WHEN

A phased roadmap for the rollout of the European Energy Data Space could be structured as follows:

- **Phase 1 (2026-2027): Pilot & Sandbox**
  Launch with a small number of volunteer operators and a limited set of high-value datasets. This phase focuses on validating the foundational building blocks of the Energy Data Space, including interoperability, trust frameworks, and early marketplace functionalities. Regulatory sandboxes and pilot projects will be the key instruments for moving from theory to practice and demonstrating tangible value. Key activities include: Establishing the legal and technical frameworks for data sharing; Developing and applying standardised semantic data models (ontologies) to ensure cross-domain and cross-sector interoperability; Designing and testing AI/ML tools for edge and cloud levels; Running large-scale pilots and sandboxes (e.g., ENERSHARE, HEDGE IoT, EnerTEF, Crete Valley, META BUILD, ENPOWER) to test core functionalities; Ensuring continuous participation in Horizon Europe calls supporting common European data space development.
- **Phase 2 (2028-2030): Scaled Deployment**
  Expand participation to a larger group of operators and datasets, moving from pilots to broader deployment. Objectives include: Scaling secure, interoperable data exchange platforms across Member States; Enabling cross-border data sharing for non-sensitive datasets; Driving market uptake by integrating advanced AI-enabled services and digital twin applications into operational environments; Intensifying alignment with EU-level initiatives (GAIA-X, IDSA, BRIDGE) and international standardisation bodies to ensure harmonisation; Expand to include additional renewable vectors, such as geothermal energy data exchanges for heating and storage applications, ensuring interoperability with electricity and district heating systems.
- **Phase 3 (Post-2030): Full Integration**
  Achieve a fully operational and federated European Energy Data Space, covering all relevant sectors and supporting advanced cross-border operations. This phase ensures: Integration of safety-critical and sensitive data under mature regulatory oversight and cybersecurity frameworks; A coherent and interoperable data infrastructure across all Member States; Sustainable governance and business models, ensuring the Energy Data Space becomes a permanent enabler of market integration, flexibility, and innovation in line with the Clean Energy Package and EU Digital Decade goals.

KEY PERFORMANCE INDICATORS (KPIS)

Proposed KPIs to monitor implementation include:

- Number of Thematic Visions, IICs (for IWGs) and Strategic Research and Innovation Agendas (for ETIPs) explicitly integrating data space-related R&I activities, counting how many of the official action plans (from IWGs) and long-term research strategies (from ETIPs) directly mention and include projects or objectives related to building or using energy data spaces.
- Number of energy data space-compliant connectors and middleware deployments facilitating data exchange across different energy domains. This KPI indicates the actual physical and software infrastructure being built to enable data sharing.
- Increase in consumer participation in energy data sharing (e.g., via data cooperatives, engagement in services). This tracks engagement with data-driven energy services, showcasing the level of social trust and the real-world uptake of data sharing.
- Number of AI-based services and Digital Twin applications hosted and utilised on data space platforms. This KPI can measure the actual value being created from the shared data, showcasing that it is not about moving data but about enabling advanced analytics services.

RECOMMENDATION 8: DEVELOP A EUROPEAN ENERGY DATA SPACE ROLLOUT PLAN

Recommendation summary:

The rapid digitalisation of the energy system creates significant new cybersecurity risks, with the proliferation of interconnected IoT devices, distributed energy resources and complex data platforms exposing the sector to an expanded threat landscape. Gaps in EU-wide standards and the inadequacy of traditional perimeter-based security models compound this challenge.

This recommendation promotes R&I activities contributing to a cyber-resilient architecture for digitalised energy systems, ensuring that future energy infrastructures are secure-by-design.

IWGs, ETIPs, EERA, and CETP are recommended to promote projects implementing a holistic defence-in-depth approach spanning from IoT devices and smart meters to substation automation systems, SCADA platforms and central control systems, with a strong focus on convergence of information and operational technology. Through collaborative projects, pilots and knowledge exchange, these SET Plan groups can foster the development and deployment of secure data models and trusted data-exchange frameworks, thereby strengthening the resilience and security of critical energy infrastructures.

Box 8: Operationalisation of Recommendation 8 – Cyber resilience action plan

ETIPs and IWGs should promote R&I activities contributing to a cyber-resilient architecture for digitalised energy systems, ensuring that future energy infrastructures are secure-by-design. Their work should address cybersecurity challenges associated with increasingly digitalised and decentralised energy systems, including distributed energy resources, renewable generation, IoT devices and edge computing systems. In particular, they should promote projects that implement a holistic defence-in-depth approach spanning from IoT devices and smart meters to substation automation systems, SCADA platforms, and central control systems, with a strong focus on IT/OT convergence. Through collaborative projects, pilots and knowledge exchange, ETIPs and IWGs can also foster the development and deployment of secure data models and trusted data-exchange frameworks for use in energy systems. These efforts will strengthen the resilience and security of critical energy infrastructures while supporting the safe deployment of digital technologies across the European energy sector.

WHY

Challenges identified by TF members and literature review

The rapid digitalisation of the energy system creates significant new cybersecurity risks[113] while the reliance on millions of interconnected IoT devices, distributed energy resources and complex data platforms exposes the sector to new vulnerabilities[114]. SET Plan explicitly identifies 'resilience and security of energy systems' as one of its ten strategic R&I priorities, as stated in the revised 2023 Communication:

- **An expanded and more complex threat landscape:** The integration of Information Technology (IT) and Operational Technology (OT) systems, coupled with the proliferation of IoT and edge devices, exponentially increases the potential attack surface. This exposes critical infrastructure to network vulnerabilities and data breaches, a trend officially documented in regular threat landscape reports from the European Union Agency for Cybersecurity (ENISA)[115]. The CERT-EU Threat Landscape Report 2023 indicates that the energy sector was one of the most targeted sectors, reflecting the heightened vulnerability of energy-related infrastructures[116].
- **Gaps in EU-wide standards and certification:** A key barrier is the lack of harmonised cybersecurity standards and certification schemes specifically for the energy sector, a gap that persists despite the framework established by the EU

113 https://energy.ec.europa.eu/topics/eus-energy-system/digitalisation-energy-system_en
114 Zografopoulos I., Hatziargyriou N.D., Konstantinou C. (2023). Distributed energy resources cybersecurity outlook: Vulnerabilities, attacks, impacts, and mitigations. IEEE Systems Journal 17 (4), 6695-6709
115 https://www.enisa.europa.eu/publications/enisa-threat-landscape-2024
116 https://cert.europa.eu/publications/threat-intelligence/tlr2023

Cybersecurity Act (Regulation (EU) 2019/881)[117]. This fragmentation results in an inconsistent security posture across Member States and hinders the development of a trusted market for secure energy technologies.

- **Inadequacy of traditional security for decentralised systems:** As the energy system becomes more decentralised, the heightened security obligations for operators under the NIS2 Directive (Directive (EU) 2022/2555[118]) highlight that traditional, perimeter-based models are no longer sufficient. Significant progress was made in March 2024, when the Commission adopted the first EU network code on electricity-sector cybersecurity, operationalising key SET Plan digitalisation aims and aligning with NIS2 risk management structures[119]. A proactive "security-by-design" approach is required to address threats that can emerge from any point in the system.

Expected outcomes and contribution to EU priorities

By creating a proactive and harmonised approach to cybersecurity, this action plan will build the confidence needed for all energy system value chain stakeholders to invest in, adopt, and rely on new digital solutions. The expected outcome can encompass:

- Major contribution to the implementation of the NIS2 Directive: A dedicated Cyber Resilience Action Plan will provide a clear, sector-specific roadmap for energy entities to implement the stringent cybersecurity risk-management measures and incident reporting obligations required for operators of essential services under the Directive (EU) 2022/2555.
- Direct support for the EU Cybersecurity Act: This recommendation operationalises the framework established by the Cybersecurity Act by driving the creation of tailored certification schemes for the energy sector. Specifically, the action plan would define the scope and assurance levels for these schemes, leading to the certification of critical ICT products (e.g., smart meters, grid controllers, IoT gateways), services (e.g., data exchange platforms, flexibility aggregation services), and processes (e.g., secure software development lifecycles for energy applications) ensuring a transparent and trustworthy market and allowing operators to procure certified-secure components.
- Acceleration of the Digitalisation of Energy Action Plan (DoEAP): This recommendation underpins the entire DoEAP by ensuring that the digital transformation of the energy sector is built on a resilient foundation. Specifically, it provides the strategic foundation needed to develop and implement the legally binding 'network code on cybersecurity for cross-border electricity flows' called for in the action plan. The Cyber Resilience Action Plan would establish the common security-by-design frameworks and harmonised standards that are essential prerequisites for drafting such a technical and effective code, ensuring the entire digital transformation is built on a resilient and trustworthy foundation.
- Enhanced resilience of Industrial Control Systems (ICS) and Operational Technology (OT): By introducing minimum mandatory cybersecurity requirements, embedding zero-trust principles, and creating EU-wide mechanisms for threat intelligence sharing and patch management, the Action Plan will strengthen the protection of high-consequence infrastructures.
- Strengthened systemic resilience of the European energy system: By incorporating cyber resilience into a broader vision of systemic resilience, the Action Plan will help energy systems withstand and recover from cyber threats, physical disruptions, climate impacts, and market shocks. This ensures that resilience is fully integrated alongside de-fossilisation and sustainable development, making it a cornerstone of the clean energy transition.
- Position security-by-design as a driver of innovation by providing innovators with clear frameworks, automated testing environments, and proportional risk-based requirements. This will accelerate the uptake of secure digital solutions across the energy sector, building trust among operators, regulators, and consumers.

117 https://eur-lex.europa.eu/eli/reg/2019/881/oj/eng
118 https://eur-lex.europa.eu/eli/dir/2022/2555/oj/eng
119 https://energy.ec.europa.eu/news/new-network-code-cybersecurity-eu-electricity-sector-2024-03-11_en

WHAT

The Cyber Resilience Action Plan must therefore be designed not in isolation, but as part of a wider resilience framework that underpins the dual imperatives of de-fossilisation and sustainable development, ensuring that security and resilience are integrated into every layer of the future energy system.

Three strategic priorities should guide its design:

- A holistic, defence-in-depth approach, covering the full energy value chain; from individual IoT devices and smart meters at the grid edge, through distributed generation and storage, up to SCADA and central control systems. This layered approach should combine prevention, detection, response, and recovery mechanisms.
- A strong focus on the IT/OT convergence challenge, addressing the vulnerabilities at the critical interface between information technology (IT) and operational technology (OT) systems. The plan should prioritise secure architectures and dedicated protocols for IT/OT integration.
- A shift from compliance to active resilience, ensuring that energy entities move beyond a "tick-box" approach to security. This means building capacities for real-time threat intelligence sharing, coordinated incident response, and rapid system recovery.

In particular, the Action Plan should include a dedicated "OT Cyber Resilience Action Plan" for critical energy infrastructures. This must address the unique vulnerabilities of Industrial Control Systems (ICS) and Operational Technology (OT).

Building on these guiding principles, the Action Plan should prioritise the following solutions:

- **Sector-Specific Certification and Harmonised Standards:** The action plan should drive the creation of EU-wide certification schemes tailored for critical energy components, software, and services. This provides a transparent and reliable way for operators to procure secure technology and for providers to demonstrate compliance with a common European security baseline. These schemes should be closely aligned with the Cyber Resilience Act and developed in cooperation with the European Union Agency for Cybersecurity (ENISA).
- **Protocols for AI and Data-Driven Model Security:** Given the increasing use of AI in grid management, specific protocols must be developed to secure the AI models themselves. The plan should provide solutions for detecting and mitigating specific AI vulnerabilities, including data poisoning, adversarial attacks, and data exfiltration.
- **A common Security-by-Design Framework:** Establish a unified framework embedding security and privacy principles throughout the lifecycle of energy systems and applications, from design to decommissioning. To make this an enabler of innovation, the framework should: Integrate security from day one of the development process, with early engagement of regulators and security experts to guide innovators; Implement a "fast-track" certification process for pre-approved, pre-tested security components (e.g., secure communication modules, cryptographic libraries); Adopt a modular certification model, where individual hardware and software components are certified once and then reused across systems, allowing developers to build solutions from a library of trusted, "secure-by-design" parts; Automate security testing and validation through EU-backed Cybersecurity Living Labs or sandboxes; Apply a risk-based approach, tailoring requirements to application criticality, to avoid stifling low-risk innovation while ensuring maximum protection for high-consequence infrastructures.

WHO

This recommendation requires coordinated action from the following key stakeholders to ensure its successful implementation:

- **EU & National Policymakers and Regulators:** This group is responsible for creating a coherent regulatory environment by transposing EU directives into national law. They could align national strategies with the EU action plan to foster a harmonised, secure market that drives innovation
- **Energy Sector Operators (TSOs & DSOs, and multi-vector operators including gas, district heating, geothermal, and hydrogen infrastructures):** As owners of critical infrastructure, they are the primary implementers of technical security measures like advanced access control and data integrity protocols. Their operational needs and real-world experience directly inform the R&I priorities within the SET Plan.
- **Technology Providers and Industry:** Their role is to adopt "security-by-design" principles to build resilience directly into all energy-related hardware, software, and platforms. They are essential for creating the market of trusted, certified technologies that operators can safely procure and deploy.
- **SET Plan ETIPs and IWGs:** Their primary role is to integrate the R&I actions of this recommendation into their Thematic Visions, IICs and SRIAs. This includes prioritising research on secure-by-design frameworks and certified components for their specific technology areas.

HOW

The SET Plan should support the development and implementation of a Cyber Resilience Action Plan through its R&I coordination role, while recognising that the broader governance of cybersecurity policy falls within the competence of the European Commission, ENISA and national authorities. To be effective, governance must be translated into concrete, time-bound actions that create trust, drive harmonisation, and accelerate R&I deployment.

- Establish a European Energy-ISAC (Information Sharing and Analysis Centre): The SET Plan should drive the creation of a formal EU-level Energy-ISAC. This public–private partnership (involving the European Commission, ENISA, TSOs, DSOs, and key technology providers) would serve as the central hub for cyber threat intelligence sharing, early-warning systems, and coordinated incident response across the Union.
- Develop a Sector-Specific Certification Framework: The SET Plan should mandate the development of an EU-wide cybersecurity certification scheme for critical energy components, systems, and services, as foreseen under the EU Cybersecurity Act. Led by ENISA, with strong technical input from the energy sector, this framework will establish mandatory minimum assurance levels and ensure that the procurement of new technologies is based on trusted, certified, secure solutions.
- Fund R&I in OT Cybersecurity: The SET Plan should guide Horizon Europe (and successor programmes) to dedicate funding to OT-specific cybersecurity challenges. Priorities include intrusion detection for industrial control protocols, secure-by-design architectures for grid-edge and IoT devices, and resilience measures for legacy OT systems and high-consequence infrastructures such as geothermal power plants, district heating networks, and mineral recovery facilities.

In parallel, indicative actions that can be taken by the IWGs and ETIPs include:

- Integrating cybersecurity R&I activities into Thematic Visions, IICs and SRIAs, prioritising secure-by-design principles and certified OT/ICS components for their technology areas.
- Developing and deploying secure data exchange frameworks, leveraging IDS-compliant connectors, federated identity management, and usage control technologies, with distributed ledger systems for trusted and tamper-proof transactions.
- Establishing transparent data and service marketplaces enriched with blockchain/smart contracts, where secure and certified services, AI-based applications, and digital twins can be validated and deployed for energy system optimisation.
- Intensifying collaboration with EU-level initiatives and standardisation bodies (GAIA-X, IDSA, BRIDGE, ETSI, IEC, ISO), ensuring that the European energy sector is aligned with international best practices and harmonised standards.

WHEN

Short-term (2026-2027)

- Formalise and adopt the Cyber-Resilient Action Plan (at EU and national Level in cooperation with Member States)
- Launch initial large-scale pilot projects to test and validate core security-by-design frameworks and trust mechanisms in real-world environments, mirroring the initial phases of current Horizon Europe projects.

Medium-term (2027-2030)

- Achieve widespread adoption of the security-by-design framework across the energy sector – national ministries and regulators for oversight.
- Establish and operationalise the first EU-wide cybersecurity certification schemes for critical energy components at the EU level

Long-term (post-2030)

- Ensure the action plan and its associated frameworks are under continuous review to adapt to the evolving threat landscape – EU level
- Mandate cybersecurity certification as a standard requirement for a wide range of new energy system products and services – EU legislator for framework and national authorities for enforcement

KEY PERFORMANCE INDICATORS (KPIS)

Proposed KPIs to monitor implementation include:

- Number of SRIAs and IPs integrating the Cyber Resilience Action Plan: This KPI directly measures the adoption of the recommendation by the core SET Plan stakeholder groups. It tracks how many ETIPs and IWGs have formally included dedicated R&I activities on security-by-design in their strategic documents.
- Number of EU-wide cybersecurity certification schemes established for the energy sector: This KPI tracks the creation of new, harmonised certification schemes for critical energy components and software, as envisioned by the EU Cybersecurity Act.
- Measured reduction in the number and severity of cybersecurity incidents reported by energy operators, measuring whether the implemented frameworks and technologies are succeeding in making the EU energy system more resilient and secure against cyber threats.

ANNEXES

ANNEX 1: PARTICIPANTS OF THE TASK FORCE

The table below lists those who participated in the Task Force and contributed to developing the recommendations. .

Table A1: Participants of the Task Force

Name (Role/Organisation)
Support Office (including experts)
• Andreas Pauer (Support Office) • Alessandro Gasparotti (Support Office) • Dominique Schmutzer (Support Office) • Joao Pecas Lopes (Lead Expert) • Vangelis Marinakis (Support expert) • Susana Martin Toral (Support expert) • Pierluigi Siano (Support expert) • Julija Vasiljevska (Support expert)
TF members
• Greg Arrowsmith (ETIP PV) • Angela Berger (IWG ES) • Ana Bernardos Garcia (IWG CST) • Eduard Doujak (ETIP HYDRO) • Tuhfe Gocmen (ETIP WIND) • Christoph Gollner (IWG PED) • Nikos Hatziargyriou (ETIP SNET) • Patrik Klintbom (ETIP BIO) • Ruairi MacIver (IWG Ocean) • Henrik Madsen (IWG EEB) • Rafael Mayo-García (EERA) • Tina Ringenson (CETP) • Christophe Schneidesch (ETIP SNETP) • Javier Urchueguia (ETIP GEO) • Szabolcs Szávai (IWG NS) • Salvatore D'Arco – DCT)
European Commission (Observers)
• George Mugurel Paunescu (Lead Policy Officer, DG ENER)

ANNEX 2: METHODOLOGY OF THE TASK FORCE

The sections below describe the main elements of the approach for developing recommendations within a Task Force:

1. Nomination of Task Force members
2. Task Force meetings
3. Literature review
4. Conceptual Framework
5. Consolidated Priority Framework
6. Consultation with wider SET Plan community

1. Nomination of Task Force members

The following 'stakeholder groups' of the SET Plan were invited to nominate representatives to participate in the Task Forces:

- Implementation Working Groups (IWGs);
- European Technology and Innovation Platforms (ETIPs);
- European Energy Research Alliance (EERA);
- Clean Energy Transition (CET) Partnership;
- Driving Urban Transition (DUT) Partnership

Each SET Plan stakeholder group (i.e., a specific ETIP or IWG) could nominate one primary representative for each cross-cutting Task Force. A call for expressions of interest was launched in Q3 2024 to gather nominations and establish the members of each Task Force. The European Commission Policy Officers had an observer role.

There are specific roles within the Task Force that facilitated the co-creation of recommendations. These are described in the table below.

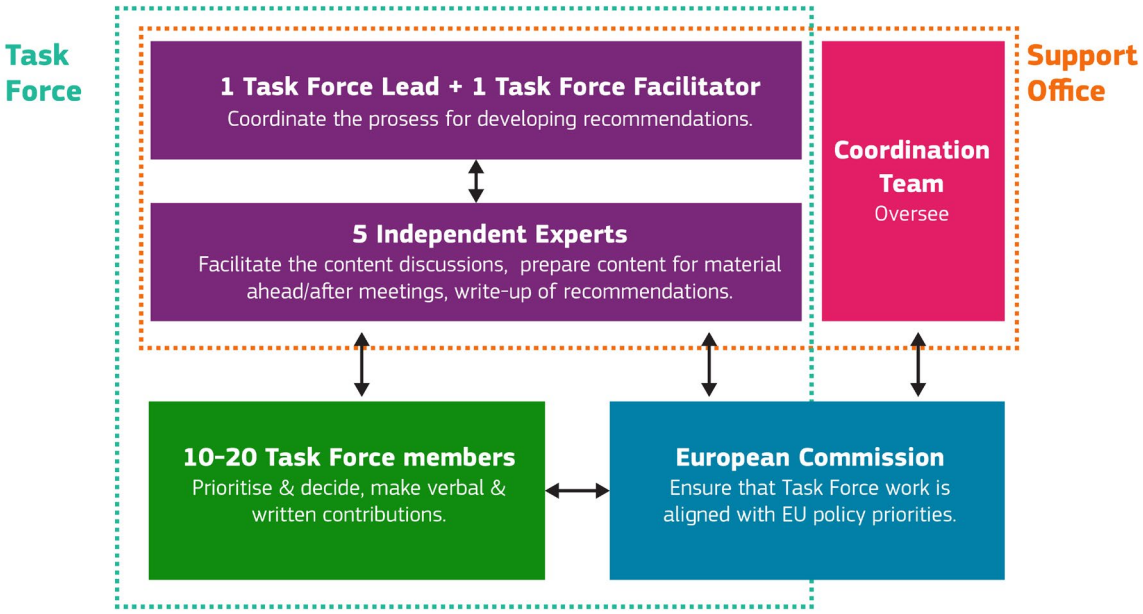
Table A2: Overview of roles for each Task Force

Role	Description
Support Office (7+)	The Support Office operated the Task Forces and was made up of: • Coordination team overseeing the operation of the five Task Forces. • 1 Task Force Lead and 1 Task Force Facilitator to coordinate the meetings (incl. logistics and minutes) and outputs of the Task Forces. • 5 Independent Experts who provided knowledge and guidance in their specialised fields and wrote up (specific aspects of) the recommendations. They were 'independent' in the sense that they had not previously been involved in the SET Plan.
Members of the Task Forces (10 – 20)	Representatives were nominated by the SET Plan stakeholder groups (ETIPs, IWGs, etc.). Specific responsibilities for Task Force members included: • Attend all meetings of the Task Force (3-4 online meetings took place over 2025); • In between meetings: Gather feedback from the SET Plan stakeholder group they represent and provide written inputs (e.g. survey); • During meetings: Make verbal contributions (e.g. rank and decide on priorities and solutions) Inputs from Task Force members have helped develop the Conceptual Framework.

European Commission (2+)	• European Commission Policy Officers had an observer role in the recommendation development process.
	• 'Lead' Policy Officers (LPO): Ensured that the work of the Task Force was aligned and reflected the policy priorities of the Commission.
	  • They reviewed the documents before they were published and shared with members and approved recommendations from the Task Force.
	  • They did not directly influence the process of the recommendations.
	'Other' Policy Officers: Provided oral and written inputs on an as-needed basis (e.g. for a specific policy area).

Overall, the Support Office served as a facilitator, drawing on the knowledge of SET Plan stakeholder groups. With the help of independent Experts, the Support Office structured discussions and helped identify gaps and challenges for Task Force members.

Figure A1: Roles of the Task Force and Support Office



2. Task Force meetings

For each Task Force, the following meetings were held to facilitate the development of the draft recommendations.

The **first Task Force meeting, held on 11 March 2025**, served as an initial discussion point for preliminary priorities related to digitalisation. These preliminary priorities included:

- Digital tools (e.g., Digital Twins, Artificial Intelligence, IoT, 3D subsurface imaging, big data, physical sensors, robotics);
- Use-cases (e.g., management of the energy system, monitoring and predictive maintenance); and
- Cross-cutting topics such as collection and exchange of data, and security.

However, it was noted during this meeting that the structure of these preliminary priorities had some overlaps and lacked mutual exclusivity. Consequently, the Support Office undertook the task of revising these priorities to propose a more structured framework. The Consolidated Priority Framework is available under Annex 4.

The second Task Force meeting was held on 26 June 2025 and participants agreed on a Consolidated Priority Framework. This revised framework adopted a mixed approach, organised around two main axes: digital-related priorities (digital enablers) and energy-related priorities (high-level use cases). This structure enabled a bottom-up approach where energy-related priorities guided the selection and application of digital enablers.

During this second meeting, Task Force members not only **broadly agreed with the identified barriers** for each priority but also **provided valuable input on potential solutions**. While the meeting proved very useful, most of the discussions, potential solutions, and, therefore, the basis for recommendations revolved around data rather than digital tools more broadly. Independent experts developed these draft recommendations and are open and committed to developing further ones to cover digital tools more broadly. Initial feedback and wider consultation tools will be invaluable in understanding the form such additional recommendation(s) could take.

The third Task Force meeting was held on 9 March 2026 and focused on the presentation as well as the validation of the revised recommendations. Task Force members provided their final input and feedback and validated the recommendations.

Alongside the Task Force meetings, several meetings were held with the Task Force Lead, Facilitator, and the experts to discuss input, develop the recommendations and support preparation for Task Force Meetings.

3. Literature review

Between October 2024 and April 2026, literature was reviewed by the Support Office and the Independent Experts. The literature review serves as supporting evidence.

4. Conceptual Framework

A preliminary Conceptual Framework was developed for each cross-cutting topic ahead of the 1st Task Force meeting. It facilitated the process of developing recommendations by supporting the identification of:

- **Barriers and gaps:** A barrier is something that acts as a hindrance or obstacle. A gap signifies a lack of separation. Both need to be addressed to progress on a cross-cutting topic.
- **Solutions:** Practical approaches which address a specific barrier or gap.
- **Recommendations:** In the context of the SET Plan, solutions were refined to be effective, feasible and appropriate.

The initial Conceptual Framework included input from:

- The survey used to collect Expressions of Interest (EoI) and recruit Task Force members (launched in Summer 2024).
- A Cluster Workshop (November 2024), which brought together the Secretariats of the Implementation Working Groups (IWGs) and the European Technology & Innovation Platforms (ETIPs) of the SET Plan. The objective of the workshop was to identify their priorities across five cross-cutting topics to inform the future work of the respective Task Forces.
- Research conducted by the Support Office on the EU Policy landscape relevant for the cross-cutting topics.
- Feedback received by Independent Experts of the Task Force.

5. Consolidated Priority Framework

During the first Task Force meeting, the ranking of priorities, based on the onboarding survey, served as a starting point for discussion. These were validated as commonly recognised as relevant for the TF as a whole:

- Collection and Exchange of data
- Digital tools: AI
- Digital tools: Digital twins
- Use-case: Management of the energy system
- Security

Participants have presented different perspectives on how to frame priorities and their unique challenges, suggesting a bottom-up and a top-down approach to frame them. No consensus could be found on how to proceed during the first meeting. Based on the outputs of the first TF Meeting, the support office (composed of the Task Force lead, facilitator, and experts) took over the task of revising the existing priorities and proposing a way forward.

Following an internal analysis, a mixed approach was adopted for the definition of the priority framework under the scope of the Digitalisation Task Force. This approach is organised around two main axes: digital-related priorities and energy-related priorities (see Figure 1).

- The **digital-related priorities** define a set of digital enablers that are commonly required to develop digitally enhanced energy services and solutions.
- The **energy-related priorities**, associated to high level use cases, identify key topics where the digitalisation of the energy system could contribute to improved efficiency and sustainability.

The implementation of this priority framework was based on a bottom-up approach (from specific Use Cases to general digital technologies), where energy-related priorities will steer the selection and use of digital enablers. For each enabler, specific gaps, barriers, potential solutions, and tailored recommendations were systematically identified.

Guided by concrete Use Cases, the analysis addressed the identification of problem-solution pairs for each digital enabler, examining challenges such as: (1) Data availability, accessibility, and data quality; (2) Interoperability issues (standard data models/ontologies/ protocols); (3)Data Management, storage and data sharing mechanisms; (4) Cybersecurity and regulatory framework; (5) Digital tools (e.g. data-driven services, Digital Twins, and AI models), and provided specific recommendations at each digitalisation level.

6. Consultation with the wider SET Plan community

Following the development of the draft recommendations, a consultation was launched to collect feedback from the IWG and ETIP Secretariats and (Co-)Chairs; European Commission members; and Steering Group members. The consultation took place between the 25th of August and the 12th of September 2025. A second consultation round took place between the 9th of February and the beginning of March. Feedback from the consultation was included in the finalisation of the recommendations on cross-cutting topics to be addressed by/within the SET Plan.