European Commission

European Technology and Innovation Platform Smart Networks for Energy Transition (ETIP SNET)

R&I Implementation Plan 2025+

ETIP SNET

European Technology and Innovation Platform Smart Networks for Energy Transition

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Glossary and Acronyms

Active Demand	(see Demand Side Response)
Advanced Meter Management (AMM)	software that performs long-term data storage and management for the vast quantities of data delivered by smart metering systems.
Advanced Metering Infrastructure (AMI):	is an integrated system of smart meters, communications networks, and data management systems that enables two-way communication between utilities and customers.
Aggregator:	Data Responsible who aggregates according to a defined set of market rules, e.g. of power generating modules, demand units and/or reserve providing units.
Alternating current (AC):	an electric current which periodically reverses direction.
Ancillary services:	a service necessary for the operation of an electricity transmission or distribution system to support the electric power from seller to purchaser given the obligations of control areas and to maintain reliable operations of the interconnected electricity system.
Application Program Interface (API):	is a set of routines, protocols, and tools for building software applications. Basically, an API specifies how software components should interact. Additionally, APIs are used when programming Graphical User Interface (GUI) components.
Artificial Intelligence (AI):	Algorithms emulating the intelligence of human brain
Asset:	an asset is something valuable or useful. Tangible assets are fixed such as buildings, equipment etc.; an asset is part of a TSO operator control area or located in a distribution system.
Balance Responsible Party (BRP):	means a market participant or its chosen representative responsible for its imbalances in the electricity market.
Balancing Service Providers (BSP):	in the European Union Internal Electricity Market, this is a market participant providing balancing services to its Connecting TSO, or in case of the TSO-BSP Model, to its Contracting TSO.
Blockchain:	a system in which a record of transactions made in bitcoin, or another cryptocurrency are maintained across several computers that are linked in a peer-to-peer network.
Carbon-neutral:	situations where the energy system consumes as much CO_2 as it emits; the CO_2 balance is equal to zero.
Capital Expenditures (CAPEX):	budget spent to buy or upgrade fixed assets
Citizen:	use for people who value the development of smart grids as an opportunity to realise "We-centred" needs or motivations, e.g. affiliation, self-acceptance or community. Citizens want to help ensure the quality of supply and support environmental preservation and the community.
Cogeneration:	simultaneous production of electricity and useful heat. In a regular power plant, the heat produced in the generation of electricity is lost, often through the chimneys. But in a cogeneration plant it is recovered for use in homes, businesses, and industry. A tri-generation plant, or Combined Cooling, Heat and Power (CCHP), produces cooling (air conditioning) as well as heat and electricity.
Combined Heat and Power (CHP):	is an energy efficient technology that generates electricity and captures the heat that would otherwise be wasted to provide useful thermal energy—such as steam or hot water—that can be used for space heating, cooling, domestic hot water and industrial processes.
Common information model (CIM):	is an open standard that defines how managed elements in an IT environment are represented as a common set of objects and relationships between them.

Consumer:	Role of the energy user for electricity, heat and chemical energy (e.g. gas) classified in industrial consumers, consumers providing transport systems, consumers for a commercial entity or commercial building and residential consumers.
Contingency:	an event (such as an emergency) that may but is not certain to occur. In power systems, a contingency is when an element such as a transmission line or a generator, or the electric grid fails.
Conversion technology (-ies):	any system that converts energy from one form to another (e.g. electricity, heat, work, and motion).
Customer / End-user:	an end-user of energy.
Cybersecurity:	all mechanisms and processes for guaranteeing the integrity of the operation of computer systems in the event of attacks and malfunctioning.
Demand side flexibility:	The capacity to change electricity usage by end-use customers (including residential) from their normal or current consumption patterns in response to market signals, such as time-variable electricity prices or incentive payments, or in response to acceptance of the consumer's bid, alone or through aggregation, to sell demand reduction/increase at a price in organised electricity markets or for internal portfolio optimisation.
Demand Side Response (DSR) / Active Demand:	is a change in the power consumption of an electric utility customer to better match the demand for power with the supply. It is the capacity to change electricity usage by end-use customers (including residential) from their normal or current consumption patterns in response to market signals, such as time-variable electricity prices or incentive payments, or in response to acceptance of the consumer's bid, alone or through aggregation, to sell demand reduction/increase at a price in organised electricity markets or for internal portfolio optimisation
Digital twin:	refers to a digital replica of physical assets, processes and systems that can be used for various purposes e.g. simulation and modelling. The digital representation provides both the elements and the dynamics of how an Industrial Internet of Things device operates and lives throughout its life cycle including continuous digital predictions through machine learning and artificial intelligence.
Direct current (DC):	is the unidirectional flow of electric charge.
Distributed system:	systems that are installed at or near the location where the electricity is used, as opposed to central systems that supply electricity to grids. A residential photovoltaic system is a distributed system.
Distribution/Transmission System Operators (DSO/TSO):	role for operating distribution/ transmission grids of electricity supply, who plans, builds and maintains distribution/transmission infrastructure responsible for grid access and integration of renewables, grid stability, load balancing and connections to grid users (generators and consumers) at distribution/transmission grid level. Furthermore, a DSO/TSO is responsible for its interconnections with other systems and to ensure the long-term ability of the system to meet reasonable demands for the distribution/transmission of electricity or gas.
Electric Vehicle (EV):	A vehicle equipped with electric motor for propulsion.
Electromagnetic Fields (EMF):	An electromagnetic field is created by moving electric charges
End-user	(see Consumer)
Energy Community / Citizen energy community / Local Energy Community (LEC):	a legal entity where citizens, SMEs and local authorities come together, as final users of energy, to cooperate in the generation, consumption distribution, storage (such as batteries, hot water, (CO2-neutral or free) gases), supply, aggregation of energy from renewable sources, or offer energy efficiency/demand side management services.
Energy Management Systems (EMS):	A modular system that manages power stations and the network

Energy storage:	system domain for appliances and assets storing energy within the group energy consuming units
Energy systems:	electricity, gas, heating and cooling, liquid fuel systems, and other energy carriers (any system or substance that contains energy for conversion as usable energy later) are all considered "energy systems".
European Telecommunications Standards Institute (ETSI) Flexible AC Transmission / Distribution Systems (FACTS/FACDS):	is a system composed of static equipment used for the AC transmission / distribution of electrical energy. It is meant to enhance controllability and increase power transfer / distribution capability of the network. It is generally a power electronics-based system.
Functionality:	range of impacts suited to achieve a specific purpose.
Gas to Heat (GtH):	combustion of gases to generate heat.
Gas to Power (GtP):	combustion of gas to generate electricity.
Gas to Power and Heat (GtP&H):	combustion of gases to generate at the same time and with high efficiency electricity and heat.
General Data Protection Regulation GDPR:	(EU) 2016/679 (GDPR) is a regulation in EU law on data protection and privacy in the European Union (EU) and the European Economic Area (EEA). It also addresses the transfer of personal data outside the EU and EEA areas.
Green gas:	is gas derived from the processing of organic waste or is hydrogen produced by renewable electricity from water.
Geographic Information system (GIS):	framework for the management and analysis spatial and geographic data
Grid to vehicle (G2V):	smart charging of s (see Smart Charging).
Hierarchical control:	is a form of control system in which a set of devices and governing software is arranged in a hierarchical tree.
High Level Use Case (HLUC)	A HLUC represents the practical realisation-related dimension to achieve the integrated energy system needs of the year 2031
High voltage (HV):	usually considered any AC voltage over approximately 35,000 volts.
Holistic Architecture:	Holistic energy system architectures facilitate all processes which are necessary for a reliable, economic and environmentally- friendly operation of integrated smart energy systems with multiple energy carriers, having electricity grids as its backbone.
Information technology (IT):	is the use of computers to store, retrieve, transmit, and manipulate data or information.
Institute of Electrical and Electronic Engineers (IEEE):	here intended as standardisation body.
International Electrotechnical Commission (IEC):	here intended as standardisation body.
Internet of Things (IoT):	is a system of interrelated computing devices, mechanical and digital machines provided with Unique Identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.
Interoperability:	the ability of two or more networks, systems, devices, applications, or components to interwork, to exchange and use information in order to perform required functions.

Levelised Cost Of Electricity (LCOE):	is a measure of a power source that allows comparison of different methods of electricity generation on a consistent basis. The LCOE can also be regarded as the minimum constant price at which electricity must be sold in order to break even over the lifetime of the project.
Liquid to Power (LtP):	Combustion of liquid fuel to generate power.
Load Frequency Control (LFC):	is used to allow an area to first meet its own load demands, then to assist in returning the steady-state frequency of the system to the nominal value.
Load shifting:	shifting large electrical loads from high-demand peak times to times where generation and shifted load match better.
Low-carbon:	situation where the CO_2 balance (i.e. emissions vs sinks) is almost zero.
Low voltage (LV):	usually refers to AC voltages from 50 volts to below 1,000 volts.
Machine to Machine (M2M):	is direct communication between devices; it can include industrial instrumentation, enabling a sensor or meter to communicate the information it records to application software that can use it.
Machine Learning (ML):	the scientific study of algorithms and statistical models that computer systems use to perform a specific task.
Medium voltage (MV):	usually refers to AC voltages between 1,000 volts to 35,000 volts.
Multi-access Edge Computing (MEC):	a network architecture concept that enables cloud computing capabilities and an IT service environment at the edge of the cellular network and, more in general at the edge of any network.
Near Zero Energy Building (NZEB):	a building with zero net energy consumption, meaning the total amount of energy used by the building on an annual basis is equal to the amount of renewable energy created on the site or in other definitions by renewable energy sources offsite.
Net Transfer Capacity (NTC):	the maximum total exchange program between two adjacent control areas compatible with security standards applicable in all control areas of the synchronous area and taking into account the technical uncertainties on future network conditions.
On load tap changer (OLTC):	is a tap changer in applications where a supply interruption during a tap change is unacceptable.
Operational Expenditures (OPEX):	OPEX is the cost for operating a product, business, or system
Organic Rankine Cycle (ORC):	is a type of power plant using, instead of conventional (water/steam) an organic, high molecular mass fluid with a liquid-vapor phase change, or boiling point, occurring at a lower temperature than the water-steam phase change.
Overhead Transmission (OT):	Electric power transmission through overhead power lines
Phasor Measurement Unit (PMU):	is a device used to estimate the magnitude and phase angle of an electrical phasor quantity (such as voltage or current) in the electricity grid using a common time source for synchronisation
Phase Shifting Transformer (PST):	is a specialised form of transformer used to control the flow of active power on three-phase electric transmission lines
Point of Common Coupling (PCC):	the point at which the interconnection between the public utility's system and the interconnection customer's equipment interface occurs.
Power Electronics (PE):	is the application of solid-state electronics to the control and conversion of electric power.
Power Quality (PQ):	involves voltage, frequency, and waveform. Good power quality can be defined as a steady supply voltage that stays within the prescribed range, steady AC frequency close to the rated value, and smooth voltage curve waveform (resembles a sine wave).

Power system stability:	is the ability of an electric power system, for a given initial operating condition, to regain a state of operating equilibrium after being subjected to a physical disturbance, with most system variables bounded so that practically the entire system remains intact.
Power to Gas (PtG):	conversion of electrical power to a gas fuel. As an example of such conversion, electricity is used to split water into hydrogen and oxygen using the electrolysis principle, where hydrogen can then be converted to methane with CO_2 as input.
Power to Heat (PtH):	conversion of electrical power into heat/cooling. The conversion can be done for example by using conventional electric heaters or heat pump systems.
Power to Gas and Heat (PtG&H):	conversion of electrical power to both gas and heat/cooling at the same time.
Power to Liquid (PtL):	process consisting in generating a synthetic liquid fuel by using renewable electricity, carbon dioxide from the atmosphere or other sources, and water.
Power to Water (PtW):	use of electrical power to pump water into higher-up hydro reservoirs and hydro dams for energy storage.
Priority Project Concept (PPC):	Projects covering all integration features of the Future Energy Systems with concrete goals and time schedule.
Prosumers:	consumers of all types (households, tertiary, industry, transport and agriculture sectors) who also produce energy. Prosumers can be active market participants by engaging in the real-time control of their energy-consuming and producing devices.
Reliability:	all the measures of the ability of the system, generally given as numerical indices, to deliver electricity to all points of utilisation within acceptable standards and in the amounts desired.
Renewable Energy Sources (RES):	energy derived from natural processes that are replenished constantly. In its various forms, it derives directly from the sun, or from heat generated deep within the earth. Included in the definition are electricity and heat generated from solar, wind, ocean, hydropower, biomass, geothermal resources, and biofuels and hydrogen derived from renewable resources.
Resilience:	ability of the system with generating sources, transmission and distribution, conversion – to withstand high-impact, low-frequency events. This includes events that are natural, such as hurricanes or ice storms, as well as man-made, such as cyber or physical attacks on e.g. grid infrastructure.
Scalability:	capability of being easily expanded as larger service or more powerful product, e.g. to include more participants, a higher load or more RES
Security of Supply:	the capability of a power system at a given moment in time to perform its supply function in the case of a fault
Small And Medium size Enterprise (SME):	Enterprises with less than 50 employees and less than 50M€ turnover.
Smart Charging:	charging system where electric vehicles, charging stations and charging operators share data connections. Through smart charging, the charging stations may monitor, manage, and restrict the use of charging devices to optimise energy consumption.
Smart Grid:	an electricity network that can intelligently integrate the actions of all actors connected to it – operators of storage capacity (such as of batteries, (CO2-neutral or free) gases and liquids), generators and consumers – in order to efficiently deliver sustainable, economic and secure electricity supplies (European Technology Platform SmartGrids, 2010).
Smart Metering:	the technology of recording usage in real time from metering devices and providing a two-way communication and/or control path extending from energy network to customer appliances

Smart Transformer / Solid State Transformer / Intelligent Transformer:	a power transformer which transfers power between power networks at two voltage levels (usually corresponding to MV and LV levels) by using power electronics (“solid state”) and an internal power transformer operating at high frequency; it has usually also internal DC busbars, possible extensions of electrical energy storage and has local control which allows a flexible and smart power exchange between the two power grids. Smart Transformers are considered as an enabling technology in the future distribution grids.
State of Health (SoH):	is a figure of merit of the condition of an asset, e.g. a battery (or a cell, or a battery pack), compared to its ideal conditions
Subsidiarity:	The subsidiarity principle means that energy systems are operated in such a way that actions are optimised locally (at the most immediate level). Actions that cannot be handled locally are handled at the next level.
System architecture:	a set of conventions, rules, and standards employed in a computer system's technical framework, plus customer requirements and specifications, that the system's manufacturer (or a system integrator) follows in designing (or integrating) the system's various components (such as hardware, software and networks).
Ten Years Network Development Plan (TYNDP):	provides an overview of the European electricity transmission infrastructure and its future developments and maps the integrated network according to a range of development scenarios.
TOTal EXpenditures (TOTEX):	CAPEX (Capital Expenditures) + OPEX (Operational Expenditures)
Transmission System Operators (TSO):	see DSO / TSO
Vehicle to grid (V2G):	feeding power and energy from the vehicle battery to the grid at the connection point.
Virtual power plant (VPP):	is a cloud-based distributed power plant that aggregates the capacities of heterogeneous distributed energy resources (DER) for the purposes of enhancing power generation, as well as trading or selling power on the electricity market.
Vulnerability:	the openness to attack or damage.
Water to Power (WtP):	is power derived from the energy of falling or fast-running water; in the future also from waves.
Web of cells (energy cell):	compound comprehensive smart energy systems with subsidiary structures on the basis of decentralised generation and storage as well as decentralised, automated energy management in autonomously steered energy systems, which are able to run temporarily autarkic, e. g. in the case of failures.
Wide Area Measurement System (WAMS):	is technology to improve situational awareness and visibility within power system of today and future grids. It uses real time synchro phasor data to measure the state of grid that enables improvement in stability and reliability of power grid.

1

Executive Summary

1. Context

By 2050, the extensive electrification in (nearly) all sectors of the energy system, combined with large energy efficiency improvements and CO2 reductions in all sectors, should lead to a carbon-neutral energy system. It is widely understood that this will rely on the followings:

- The massive use of renewables for electricity, heating & cooling and transport;
- Smart Grids technologies (Digitalisation and Smart control of flexible generation and demand including sustainable buildings, districts and energy communities);
- The combination of the above with sector coupling of all energy carriers via storage (such as batteries, reverse hydro and thermal storage) and conversion technologies (for extensive use of carbon neutral gases and green fuels and hydrogen in industry, transport and buildings);
- A widely adopted circular approach of the energy systems that aims to promote collaborative business models for creating, capturing, delivering, and ultimately sharing value.

The EU "Green Deal" and related European national requirements set precise targets by 2030 in terms of:

- Decarbonisation of building stock, transport, industry, and energy systems;
- Involvement of consumers and citizen communities in energy systems;
- Digitalisation as the enabler of the environmental transition and participative energy markets;
- Reliability, adaptability and resilience of the integrated energy systems.

In order to show the view of the more than 350 ETIP SNET Stakeholders, the ETIP SNET published and updated three types of documents:

- The **ETIP SNET VISION 2050** (published 2018) provides a detailed description of this future with a set of goals to reach by 2050;
- The **ETIP SNET R&I Roadmap 2020-2030** describes the 10-year path towards this future. The Roadmap has been updated at the end of 2022, producing ETIP SNET R&I Roadmap 2022-2031;
- The **ETIP SNET R&I Implementation Plans 2022-2025 and 2025+** with a total overall proposed budget of 954 M€[1] for R&I Projects during 2025-2028. The Implementation Plans describes the details of the most urgent R&I needs to be tackled through European Commission and national R&I work programmes and calls (notably Horizon Europe Multiannual Framework).

These paths are not linear for each of the energy systems and integration goals defined for 2050. Some of the tasks and associated R&I projects will need to be deployed and implemented before others (prerequisites). Others - still - will only need to be prepared or demonstrated later, towards 2030, therefore, their deployment can be done between 2030 and 2040, and before 2050.

1.2 Synthesis of R&I High-Level Use Cases with associated budgets for the period 2025-2028

Applying a top-down stakeholder approach combined with a bottom-up analysis of the current EU Horizon Europe budgets yields:

R&I Budget Requirements: For the R&I project period 2025-2028, period of this Implementation Plan 2025+, the proposed PPCs (Project Priority Concepts) realising parts of the nine HLUCs (High-Level Use Cases) require together an estimated budget of approx. **1000 M€.**

The budgets for the Implementation Plan 2025+ (covering the period 2025-2028) have been defined through a comprehensive process by the stakeholders of the ETIP SNET. This consultative process involved actively seeking input from stakeholders at a European level regarding the budgets for each of the proposed PPCs.

By engaging stakeholders and gathering their valuable insights, the ETIP SNET ensured that a wide range of perspectives and expertise were considered in determining the budgets. This inclusive approach allowed for a holistic understanding of the funding requirements for the proposed PPCs, considering the diverse needs and priorities within the energy transition domain.

Additionally, the ETIP SNET conducted a thorough analysis of the budgets announced by the European Commission in their second work program of Horizon Europe (2023-2024) and its Cluster 5. This analysis served as a reference point, aligning the ETIP SNET's proposed budgets

[1] This budget amount represents the overall figure proposed by the ETIP SNET. It does not represent an actual investment figure.

with the broader funding framework of Horizon Europe. By considering the European Commission's budget proposals, the ETIP SNET aimed to ensure coherence and synergy with the overall European research and innovation strategy.

Furthermore, the ETIP SNET took into account the insights provided by the progress monitoring report, which analysed the ongoing research activities. This report offered valuable information about the current state of research, funding patterns, and emerging trends, allowing the ETIP SNET to make informed decisions regarding budget allocations. The following table 1 shows how the expected total budget of approx. 1000 M€ for the period 2025-2028 is allocated among the proposed HLUCs (High Level Use Cases) with their associated PPCs (Project Priority Concepts).

Table 1: The ETIP SNET R&I Implementation Plan - Period 2025-2028 with expected budgets for each HLUC

HLUC (with specific PPCs during 2025-2028)	Total Budget approx. 1000 M€ (954M€)
HLUC 1: Optimal Cross sector Integration and Grid Scale Storage	96
HLUC 2: Market-driven TSO–DSO–System User Interactions	174
HLUC 3: Pan European Wholesale Markets, Regional and Local Markets	92
HLUC 4: Massive Penetration of RES into the transmission and distribution grid	66
HLUC 5: One stop shop and Digital Technologies for market participation of consumers (citizens) at the center	164
HLUC 6: Secure operation of widespread use of power electronics at all systems levels	48
HLUC 7: Enhance System Supervision and Control including Cyber Security	208
HLUC 8: Transportation Integration & Storage	86
HLUC 9: Flexibility provision by Building, Districts and Industrial Processes	20

A short description of these 9 HLUCs is briefly repeated in this document. More information is available in the 10-year context of the [ETIP SNET R&I Roadmap 2022-2031], which has been published in March 2023.

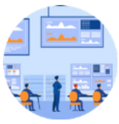
The concept of HLUCs and the associated Priority Project Concepts (PPCs) were selected to communicate to the key audiences of this ETIP SNET R&I Implementation Plan, i.e. the European Commission, the national governments, the associations and the R&I community at Institutes of Technologies, Universities, Research Centres and Labs, etc. By using and defining HLUCs, the ETIP SNET intends to underline the urgency of realising the transformation of today's energy system through concrete R&I projects into the needed (partially) renewable energy system of 2031 and the fully CO2-neutral energy system of 2050 as the ultimate goal. This is strongly connected with concrete outcomes and scopes for real-world demonstrations.

The R&I Priority Projects Concepts (PPCs) for each of HLUC should cover all integration features of the Future Energy Systems with concrete goals and time schedule.

Each PPC serves as input not only to Horizon Europe work programs and co-funded projects at European level, but also to the transnational, national and regional projects (and preceding national roadmaps, R&I Implementation Plans, work programmes and calls) among and within European countries.

As an overview, the following table contains the PPCs during this Implementation Plan 2025+. More details and also PPCs, to be probably revised and implemented in future Implementation Plan Periods until 2031 are given in Section IV of this document.

Table 2: List of Priority Project Concepts (PPCs) IP 2025+

	**HLUC 1: Optimal Cross Sector Integration and Grid Scale Storage (PPC IP 2025+)**	PPC 1.4: Integrating hydrogen and CO2-neutral gases
		PPC 1.5: Regulatory framework for cross sector integration
	**HLUC 2: Market-driven TSO–DSO– System User Interactions (PPC IP 2025+)**	PPC 2.5: Develop a Digital Twin of the European Electricity Grid
		PPC 2.6: Viable business cases through market mechanisms and incentives
		PPC 2.7: Governance for TSO, DSO and System Users (IP 2025+)
	**HLUC 3: Pan European Wholesale Markets, Regional and Local Markets (PPC IP 2025+)**	PPC 3.4: Validation of new market concepts
	**HLUC 4: Massive Penetration of RES into the Transmission and Distribution Grid (PPC IP 2025+)**	PPC 4.5: Well-functioning markets for a RES based energy system
		PPC 4.6: Policies and governance for a RES based energy system
	**HLUC 5: One Stop Shop and Digital Technologies for Market Participation of Consumers (Citizens) at the Center (PPC IP 2025+)**	PPC 5.1 Value of Consumer/Customer acceptance and engagement
		PPC 5.2: Plug and play devices and IoT (Internet of things) including security by design
		PPC 5.3: Utilisation of Communication Networks including cyber security
		PPC 5.4: Cross-sectorial flexibility use cases
		PPC 5.5: Data Spaces
		PPC 5.6: Building skills needed for developers and users of the energy system to accelerate its transition through its digitalisation
		PPC 5.7: Service management and operations
		PPC 5.8: Sharing IT infrastructure investments
	**HLUC 6: Secure - Operation of Widespread Use of Power Electronics at all System Levels (PPC IP 2025+)**	
	**HLUC 7: Enhance System Supervision and Control including Cyber Security (PPC IP 2025+)**	PPC 7.5: Grid operator of the future
		PPC 7.6 Grid field workforce of the future
		PPC 7.7: Human machine interface
		PPC 7.8: Cybersecurity of Energy Networks
	**HLUC 8: Transportation Integration & Storage (PPC IP 2025+)**	PPC 8.4: Adapting policy and market for seamless cost-effective merging of transport and energy sectors
	**HLUC 9: Flexibility Provision by Building, Districts and Industrial Processes (PPC IP 2025+**	PPC 9.4: Governance for an effective integration of buildings and smart energy communities

Details related to desired Outcomes, Scope and associated Research TASKS for each of these PPCs are given in Section V of this document. Note that only PPCs related to the Implementation Plan 2025+ are included in the work programs of this time period. The next ETIP SNET Implementation Plan (2026+) will provide details for those PPCs to be realised during 2024-2027.

This ETIP SNET R&I Implementation Plan 2025+ describes for each PPC to be implemented during this period:

- Type of PPC Action
- PPC Start/End Year
- Indicative PPC Budget
- Expected PPC Outcome
- Scope of PPC

2

Defining R&I needs for the Energy System Transition

In December 2019, the European Commission adopted the European Green Deal[2] – an ambitious plan towards EU climate neutrality by 2050, but also an overarching strategy towards decarbonising the European economy, job creation and more sustainable future for the coming generations. For Europe to be able to deliver the Green Deal, considerable steps need to be taken in terms of:

- large-scale integration of RES mostly connected to the distribution grids;
- decarbonisation of the building stock, transport, industry, and energy systems, largely through electrification;
- active engagement of consumers and citizen communities in the energy systems;
- digitalisation of the energy sector as an enabler of environmental transition and of participative energy markets;
- reductions in transport related emissions;
- increased reliability, adaptability, and resilience of the integrated energy systems.

To achieve the above ambitions, the most recent Fit for 55 package[3] embraces revision of Europe's climate, energy and transport-related legislation to align current laws with the 2030 and 2050 ambitions. As part of this package, and to align with the EU's increased climate ambition, the EU Emission Trading System Directive[4], the Renewable Energy Directive[5] and the Energy Efficiency Directive[6] have been proposed for a second revision[7,8]. Additionally, transformation of the digital sector is ongoing. To this end, the European strategy for data proposals put forward specific provisions on energy data exchanges.[9]

The latest European Commission's plan REPowerEU[10] plan takes a stance on the recent geopolitical and energy market realities and calls on EU Member States to accelerate the clean energy transition and increase Europe's energy independence. Supported by a set of financial and legal measures, it aims to accelerate the twin green and digital transition and make sure that EU citizens are at the heart of the recovery. The plan rests on three pillars – accelerated roll-out of renewable energy, energy savings and diversification of supplies.

In support of the EU Green Deal and the REPowerEU, the European Commission has recently adopted an EU action plan on the digitalisation of the energy sector[11]. It aims, among others, to ramp up investments in digitalising the EU's electricity infrastructure and bring value to the EU consumers by developing new data-driven services. A flagship proposal of the action plan is the creation of a "digital twin" of the electricity grid to facilitate coordinated investments in five key areas (network observability and controllability; efficient infrastructure and network planning; operations and simulations for a more resilient grid; active system management and forecasting to support flexibility and demand response; and data exchange between TSOs and DSOs), while strengthening cybersecurity and resilience in the energy system. In this context, implementing rules are being drafted on access to metering data, interoperability and governance as well as on cybersecurity, in line with the Electricity Directive EU 943/2019[12] and the Electricity Regulation EU 944/2019[13]. Furthermore, establishing an effective energy data sharing framework could facilitate the participation of more than 580 GW of flexible energy resources on the wholesale markets by 2050 using digital solutions[14], largely covering the overall flexibility needs of the EU electricity grids. Large part of that flexibility will be covered by enabling smart and bidirectional charging of electric vehicles, smart buildings and heating (using heat pumps) and participation of virtual power plants and energy communities in the energy markets. On a similar note, data exchange for more efficient and smarter buildings is addressed in the Commission's proposal for a revised Energy Performance of Buildings Directive, adopted in December 2021[15]. Moreover, the most recent proposal[16] for a revision of this Directive includes an obligation for EU Member States to ensure new buildings are solar ready and thus, able to install solar generation.

The transport sector accounts for nearly 25% of Green House Gas Emissions in the EU, out of which 71% is attributed to road transport[17]. In view of the urgency to enable more sustainable transport, all new cars and vans registered in Europe will be zero-emission by 2035. As an intermediary step towards zero emissions, the new CO_2 standards will also require average emissions of new cars to come down by 55% by 2030, and new vans by 50% by 2030. Additionally, the alternative fuels infrastructure regulation – part of the Fit for 55 package – sets concrete targets for deploying recharging infrastructure and alternative fuel refuelling points in the EU in the upcoming years for cars, trucks,

[2] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en
[3] https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55-the-eu-plan-for-a-green-transition/
[4] http://data.europa.eu/eli/dir/2018/410/oj
[5] http://data.europa.eu/eli/dir/2018/2001/oj
[6] http://data.europa.eu/eli/dir/2018/2002/oj
[7] https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/revision-phase-4-2021-2030_en
[8] COM (2022) 222
[9] https://digital-strategy.ec.europa.eu/en/policies/strategy-data
[10] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/repowereu-affordable-secure-and-sustainable-energy-europe_en
[11] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52022DC0552
[12] http://data.europa.eu/eli/dir/2019/944/oj
[13] http://data.europa.eu/eli/reg/2019/943/oj
[14] Digitalisation of energy flexibility', report by the Energy Transition Expertise Centre (EnTEC), https://op.europa.eu/en/publication-detail/-/publication/c230dd32-a5a2-11ec-83e1-01aa75ed71a1/language-en .
[15] COM(2021)802
[16] COM(2022) 222
[17] https://www.consilium.europa.eu/en/infographics/fit-for-55-afir-alternative-fuels-infrastructure-regulation/

planes and ships[18]. To further support the EU's climate targets, in July 2021, EU adopted the proposal for a revised Energy Taxation Directive[19], which aims to align the taxation of energy products with EU energy and climate ambitions, promote clean technologies and remove outdated exemptions so that fossil fuels can no longer be taxed below minimum rates.

In February 2023, the European Commission presented the Green Deal Industrial Plan for the Net-Zero Age[20] to support building the industrial capacity for the clean technologies relevant to deliver the Green Deal by focusing on four main pillars: creation of a predictable and simplified regulatory environment, faster access to funding, enhancing skills and facilitating open and fair trade for resilient supply chains. Moreover, in order to incentivise the clean energy transition while delivering on key objectives of energy security and affordability the European Commission presented the proposal for a reform of the Electricity Market design[21], which aims to accelerate deployment of renewables, better protect consumers, and enhance industrial competitiveness. The proposed reform[22] includes revisions to the Electricity Regulation, the Electricity Directive, and the REMIT Regulation[23]. Some of the measures, in this respect, include incentives for longer-term contracts with non-fossil power production and bringing more clean flexible solutions into the system**,** such as demand response and storage.

In view of these recent policy advancements and the clear targets set for the energy system of 2030, some key indicators are summarised below:

- **Greenhouse gas emissions in EU are reduced by 55% compared to 1990[24]** and renewable energy reaches **at least 42.5%**, while aiming for **45% of gross final energy consumption[25].**
- **Electricity becomes the dominant energy carrier in a carbon neutral economy;** electricity sectors in advanced economies reach net zero emissions by 2035, and globally by 2040 (IEA NZE Scenario[26]) with renewables growing from nearly 29% of the gross electricity generation globally, in 2021, to more than 60% by 2030[27];
- **The flexibility needs[28] of European energy systems nearly doubles by 2030** (IEA APS scenario)[29] due to changing demand patterns and rising solar PV and wind shares, largely met by demand-side flexibility, flexible low-emission generation sources and battery storage;
- **The share of electricity in transport** (except from trains, tramways) **and heating in total electricity consumption is still limited in 2030**, through for the transport sector it increases more than 20-fold till 2030 globally, especially within the light-duty vehicle segment[30]. Increased energy efficiency standards of new buildings increase the share of heat pumps;
- **Residential electricity use accounts for 30% of total electricity end-use, globally by 2030** in the (IEA NZE Scenario)**[31]** driven by an increase electricity use for heating and cooling, while stricter minimum performance standards for buildings in EU are introduced, in line with the proposal for a revised Energy Performance of Buildings Directive – yet the buildings sector needs increased efforts to get on track with the longer-term climate neutrality goal. Key measures include reduction of energy demand through clean and efficient technologies, in view of the proposal for a recast Directive on Energy Efficiency[32] and the most recent proposal for a revision of this Directive[33], but also leveraging the potential of behavioural change;
- **Household consumers (citizens) evolve into more informed and active prosumers engaged in service co-creation**, and thus becoming key contributors to the energy system transformation;
- **Industrial electricity uses shifts from 21% of the sector's final consumption to nearly 30% globally, by 2030**[34], with a greater proportion of that electricity coming from near zero emission sources, including hydrogen and carbon capture and storage.

This ETIP SNET R&I Implementation Plan 2025+ details the Research and Demonstration activities that must be performed in priority. It will be followed by three other R&I Implementation plans in order to cover all the time periods until 2030.

[18] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52022PC0384
[19] https://commission.europa.eu/document/b8f6d84f-ca48-46b9-8bb9-e76a7ac53da4_en
[20] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/green-deal-industrial-plan_en
[21] https://ec.europa.eu/commission/presscorner/detail/en/IP_23_1591
[22] https://energy.ec.europa.eu/publications/electricity-market-reform-consumers-and-annex_en
[23] http://data.europa.eu/eli/reg/2011/1227/oj
[24] https://climate.ec.europa.eu/eu-action/european-green-deal/2030-climate-target-plan_en
[25] COM/2022/222 final
[26] https://www.iea.org/reports/global-energy-and-climate-model/net-zero-emissions-by-2050-scenario-nze
[27] https://www.iea.org/reports/world-energy-outlook-2022
[28] Flexibility needs are represented by the hour-to-hour ramping requirements after removing hourly wind and solar PV production from hourly electricity demand, divided by the average hourly demand for the year
[29] https://www.iea.org/reports/global-energy-and-climate-model/announced-pledges-scenario-aps
[30] https://www.iea.org/reports/electrification
[31] https://www.iea.org/reports/world-energy-outlook-2022
[32] COM(2021) 558 final
[33] COM/2022/222 final
[34] https://www.iea.org/reports/industry

Figure 1: The ETIP SNET key steps from today via the year 2030 towards the achievement of 2050 goals

In this R&I Implementation Plan, the ETIP SNET puts emphasis on the fact that some projects with defined outcomes and goals need to be done before others (as prerequisites), while some only need to be prepared or demonstrated by 2030, so that their deployment can be done between 2030 and 2040 or later. It should be noted that the ETIP SNET R&I Implementation Plan 2025+ (for R&I Projects during the period 2025-2028) still reuses the concepts defined in the previous Vision, R&I Roadmaps and R&I Implementation Plans, such as Research Areas, Research TOPICS and Research TASKS, but is based on the key concept of **High-Level Use Cases (HLUCs)** with associated sets of **Priority Project Concepts (PPCs)** to specify more precisely the practical, including demonstration-related outcome of R&I projects as a whole. The reader interested to associate the evolution of these concepts can refer to the ETIP SNET R&I Roadmap 2022-2031.

The PPCs detailed in the next sections are intended to serve as inputs not only to “Horizon Europe” for work programs and calls for co-funded projects at European level, but also to the transnational, national and regional funding programs (with national roadmaps, R&I Implementation Plans, work programmes and calls) with their R&I projects among and within European countries.

Each PPC begins in a certain R&I Implementation Plan period, and it may need more than one Implementation Plan (four year) period until it reaches its desired outcomes. The ETIP SNET recognises that in order to reach deployment[35], research and demonstrations of these PPCs are needed not only locally, but also at country, cross-country and pan-European level.

[35] Deployment and Innovation are meant in the same way in the ETIP SNET R&I Roadmap 2020-2030. It is the phase after Research and after Demonstration.

3

The 10-year High-Level Use Cases (HLUCs) 2022-2031 and 4-year Priority Project Concepts (PPCs)

The following table describes the titles of the **9 High-Level Use Cases** (HLUCs).

Table 3: 9 HLUCs from the ETIP SNET Roadmap 2022-2031

	**HLUC 1: Optimal Cross sector Integration and Grid Scale Storage**		**HLUC 2: Market-driven TSO–DSO–System User interactions**
	**HLUC 3: Pan European Wholesale Markets, Regional and Local Markets**		**HLUC 4: Massive Penetration of RES into the transmission and distribution grid**
	**HLUC 5: One stop shop and Digital Technologies for market participation of consumers (citizens) at the center**		**HLUC 6: Secure operation of widespread use of power electronics at all systems levels**
	**HLUC 7: Enhance System Supervision and Control including Cyber Security**		**HLUC 8: Transportation Integration & Storage**
	**HLUC 9: Flexibility provision by Building, Districts and Industrial Processes**		

In this ETIP SNET R&I Implementation Plan 2025+ for each HLUC the needed **Priority Project Concepts (PPCs)** are defined. PPCs can be understood as "families for R&I projects" for the next four years 2025-2028. Each PPC is associated to one of the 9 HLUCs.

The ETIP SNET does not intend to define the individual R&I projects for each PPC: This is left to the teams proposing R&I projects to the various funding bodies in Europe (currently mainly Horizon Europe) and in the European countries.

The PPCs defined in this ETIP SNET R&I Implementation Plan 2025+ are thought to be reused and applied in the Electricity system and Energy System Integration related European and national R&I Work programs with their R&I project calls.

The ETIP SNET recognises that in order to reach deployment, demonstrations within these PPCs are needed not only locally, but also at country, cross-country and pan-European level. It is well recognised that some of the PPCs may vary when being implemented at local or national levels due to varying implementations of European legal directives, different energy system transition stages from fossil to renewable, etc.

As a consequence, different aspects of PPCs need to be demonstrated in different types of environments, such as large, medium and small size cities, communities, rural areas, mountain-areas, islands, etc. Some of the PPCs can be cross-border, regional or even pan-European.

Each PPC serves as input not only to "Horizon Europe" for work programs and co-funded projects at European level, but also to the transnational, national and regional projects (and preceding national roadmaps, R&I Implementation Plans, work programmes and calls) among and within European countries.

This ETIP SNET R&I Implementation Plan 2025+ describes for each PPC to be implemented during this period:

- Type of PPC Action
- PPC Start/End Year
- Indicative PPC Budget
- Expected PPC Outcome
- Scope of PPC

The next table enumerates all PPCs in each HLUC. The ones that feature in the column marked "ETIP SNET IP 2025+" are set to be expounded upon in this implementation plan. Those PPCs that pertain to the ETIP SNET IP 2025+ located in Annex I for reference.

Table 4: Enumeration of all PPCs in each HLUC

	ETIP SNET IP **2022-2025**	ETIP SNET IP **2025+**	ETIP SNET IP **2026+**	**LATER** ETIP SNET **IPs**
HLUC 1: Optimal Cross sector Integration and Grid Scale Storage	PPC 1.1: Value of cross sector integration and storage PPC 1.2: Control and operation tools for multi-energy systems PPC 1.3: Smart asset management for a circular economy	PPC 1.4: Integrating hydrogen and CO2-neutral gases PPC 1.5: Regulatory framework for cross sector integration	PPC 1.6: Cross sector resilience PPC 1.7: Future cross-vector infrastructure design PPC 1.8: Validation/Demonstration	
HLUC 2: Market-driven TSO–DSO–System User interactions	PPC 2.1: Market models and architecture PPC 2.2: Control and operation PPC 2.3: Platform Development PPC 2.4: Planning tools	PPC 2.5: Develop a Digital Twin of the European Electricity Grid PPC 2.6: Viable business cases through market mechanisms and incentives PPC 2.7: Governance for TSO, DSO and System Users		
HLUC 3: Pan European Wholesale Markets, Regional and Local Markets	PPC 3.1: Fundamental market design PPC 3.2: Regulatory framework and strategic investments PPC 3.3: IT systems for cross-border trading	PPC 3.4: Validation of new market concepts	PPC 3.5: IT systems for TSO/DSO control to support real time balancing	
HLUC 4: Massive RES Penetration into the Transmission and Distribution Grid	PPC 4.1: Technical barriers and technical measures PPC 4.2: Control and operation tools PPC 4.3: Infrastructure requirements and network technologies PPC 4.4: Planning for a resilient system	PPC 4.5: Well-functioning markets for a RES based energy system PPC 4.6: Policies and governance for a RES based energy system		
HLUC 5: One-Stop Shop and Digital Technologies for Market Participation of Consumers (citizens) at the Centre	PPC 5.1 Value of Consumer/Customer acceptance and engagement PPC 5.2: Plug and play devices and IoT PPC 5.3: Utilisation of Communication Networks including cyber security PPC 5.4: Cross-sectorial flexibility use cases	PPC 5.5: Data Spaces PPC 5.6: Building skills needed for developers and users of the energy system to accelerate its transition through its digitalization PPC 5.7: Service management and operations PPC 5.8: Sharing IT infrastructure investments	PPC 5.9: Large Scale Demonstration activities PPC 5.10: Creating consensus on consumer solutions	
HLUC 6: Secure operation of widespread use of power electronics at all systems levels	PPC 6.1: Control solutions for next generation inverters PPC 6.2: Hybrid transmission/distribution and hybrid distribution AC/DC grids PPC 6.3: Next Gen. distribution substation PPC 6.4: Simulation methods and digital twins		PPC 6.5: HVDC interoperability, multi-terminal configurations, meshed grids PPC 6.6: Large Scale Demonstration activities PPC 6.7: Standardisation activities	
HLUC 7: Enhance System Supervision and Control including Cyber Security	PPC 7.1: Next Gen. of TSO control room PPC 7.2: Next Gen. of DMS PPC 7.3: Next Gen. of measurements and GIS for distribution grids PPC 7.4: Wide area monitoring, control and protections	PPC 7.5: Grid operator of the future PPC 7.6: Grid field workforce of the future PPC 7.7: Human machine interface (HMI) PPC 7.8: Cybersecurity of Energy Networks	PPC 7.9: Large scale demonstration activities PPC 7.10: Standardisation activities	
HLUC 8: Transportation Integration & Storage	PPC 8.1: Technical and economic implication of decarbonisation of transport sector PPC 8.2: Enhancing effectiveness of energy system operation and resilience with electromobility PPC 8.3: Integrated planning of energy and transport sectors	PPC 8.4: Adapting policy and market for seamless cost-effective merging of transport and energy sectors	PPC 8.5: Demonstration activities	
HLUC 9: Flexibility provision by Building, Districts and Industrial Processes	PPC 9.1: Value assessment of the integration of buildings PPC 9.2: Control and operation tools for the integration of buildings PPC 9.3: Planning for reliable integration of buildings	PPC 9.4: Governance for an effective integration of buildings and smart energy communities	PPC 9.5: Evolved markets for enabling buildings and energy community facilities	
	ETIP SNET IP **2022-2025**	ETIP SNET IP **2025+**	ETIP SNET IP **2026+**	**LATER IPs**

HLUC 1: Optimal Cross sector Integration and Grid Scale Storage

The traditional energy system silos for electricity generation and end-use, for gas transport, for heating & cooling needs and for mobility/ transport must be coupled and optimised as one overall, Integrated Energy System considering P2X, X2P and large-scale energy storage technologies in order to achieve the carbon targets at lowest costs. The coupling of such complex systems needs new services based on higher degrees of automated management and control of flexible energy network resources including the conversion between them.

Energy storage technologies need to improve their integration with the grid and meet the challenges of a decarbonised energy system. Several technologies are available, and their state of the art showed different level of development and maturity. Some of these are established technologies, while others have yet to demonstrate their potential at scale. Nevertheless, all of them faces challenges that require R&I efforts to be adequate and cost-effective in a carbon-neutral energy system.

Decarbonisation of industrial sector, transport and end use energy demand at the building level, shall be supported by smart coordinated control of the interaction between energy sectors. This should also inform the role and value of alternative technologies related to energy production, transport, storage and demand sectors, from the whole-multi-vector energy system perspective / requirements, in supporting decarbonisation objectives. For an effective decarbonisation of the cross-energy sectors, sustainable environmental and social circular economy objectives should be promoted and thus foster technological and business model innovation.

It will be important to develop appropriate technical and commercial frameworks in order to coordinate sector-coupling (electricity, gas, heat, transport, etc.), the usage of all flexibility sources, and maximise the benefits of coordinated operating synergy, deployment and conflict mitigation. The ability of cross-sector coupling flexibility to enhance energy system reliability and resilience cost effectively, is an important aspect of whole-system approach to energy sector planning and operation that should be investigated. The topics above can be applied into different regional scales from buildings to microgrids or local distribution systems to national and Pan European systems.

PPC 1.1: Value of cross sector integration and storage (IP 2022-2025)

Scope of PPC: Role and value of cross sector Integration and energy storage under different future decarbonisation pathways, assessing the impact on operation and planning of energy infrastructure costs. Assessment of cost and benefits of local versus national and international approach to cross-sector integration. Role of large-scale energy storage (electricity, thermal, synthetic liquids, hydrogen, etc) in supporting cost effective decarbonisation.

- According to the Project Evaluation Report (Annex II) PPC 1.1 has been sufficiently covered by the completed and on-going projects
- According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC requires some additional funding

PPC 1.2: Control and operation tools for multi-energy systems (IP 2022-2025)

Scope of PPC: Development and demonstration of advanced technologies and control concepts /platform tools for multi- energy systems based on appropriate data exchange between different energy sectors in local, national and international regions.

According to the Project Evaluation Report (Annex II) PPC 1.2 has been covered to a certain extent by the completed and on-going projects, more R&I efforts are needed.

According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC requires some additional funding

PPC 1.3: Smart asset management for a circular economy (IP 2022-2025)

Scope of PPC: Advanced management of assets in the energy system along their entire lifecycle, deployment of IoT sensors, communication, data management & analysis and feedback to control systems. Maximise the use of existing infrastructures, compatibly with the transition speed, avoiding stranded assets.

- According to the Project Evaluation Report (Annex II) PPC 1.3 has been covered to a certain extent by the completed and on-going projects, more R&I efforts are needed.
- According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC was not adequately funded.

PPC 1.4: Integrating hydrogen and CO2-neutral gases (IP 2025+)

Scope of PPC: Development and demonstration sectoral integration of hydrogen and CO2-neutral gases with electricity system and renewables.

PPC 1.5: Regulatory framework for cross sector integration (IP 2025+)

Scope of PPC: Design of new market and regulatory frameworks that would provide business cases for cross-sector coupling in low carbon energy future, considering local, regional and international areas.

PPC 1.6: Cross sector resilience (IP 2026+)

Scope of PPC: Enhancing Security & Resilience of the energy system through optimal cross sector Integration and long duration energy storage. Enhancing resilience of interconnected regions in EU.

PPC 1.7: Future cross-vector infrastructure design (IP 2026+)

Scope of PPC: Development of the new design standards that would enable cross-sector integration and energy storage to be compared with traditional energy infrastructure design approach, while achieving appropriate security and resilience requirements.

PPC 1.8: Validation/Demonstration (IP 2026+)

Scope of PPC: Large scale demonstration projects focused on coordinated operation of cross-sector coupled energy systems, while managing synergies and conflicts between consumers and actors of the different sectors.

HLUC 2: Market-driven TSO–DSO– System User interactions

The electricity grid needs to interact with many actors or devices based on a detailed level of observability, and hence availability of data, to enable flexibility, smart charging and smart buildings. The EU's electricity network has become increasingly digitalised in the last decade, and there is a need for coordination and cooperation among operators and system users to be able to face increasing operational challenges. The recent clean energy legislation requires that electricity system operators must cooperate in planning and operating their networks. This requirement originates from different angles. On one side, there are efficiency gains in planning if information is shared, thus avoiding unnecessary investments or complexities. On the other side, both efficiency gains and increased reliability (risk reduction) can be achieved in the operation process. This cooperation aims in particular at exchange of coordinated balancing and congestion handling services (coming from DER, conventional Power Plants or controlled loads located in their grids). Additionally, sharing of forecasting information benefits a more efficient and secure energy system. All these drivers for system operators' cooperation contribute to the integration of massively increased renewable energy sources in the system, since the cooperation allows an effective, efficient and secure management of renewable sources. Increasing cross-border cooperation shall also be considered.

The cooperation between System Operators and the use of services provided to each other shall be efficient, effective and transparent. Market mechanisms should be used for this purpose. This provides for a level playing field where different types of assets and system users can compete and provide the more effective and efficient solutions for the system challenges. System Operators need, therefore, to reinforce competitive energy markets.

Furthermore, the recent policies and legislation stress the need to involve the consumer (individual, community or organisation) in the energy system, making the prosumer-related processes central in the energy system design and operation. This requires the development of adequate mechanisms for the prosumer to interact with the system operators, to contribute to the energy system operation and to participate in the energy markets. An appropriate design shall achieve both a valuable outcome for the prosumer (either financially, convenience or other) and for the operators, benefiting the energy system as a whole. Innovative tools and solutions shall be developed and tested in order to enable user-friendly interactions (e.g., by use of Social Sciences and Humanities (SSH) approaches) among and between prosumers and system operators.

This integration and cooperation between actors require adequate platforms that consider the available data, respect the defined governance and allow for seamless, transparent, non-discriminatory and cost-effective interactions.

The cooperations and interactions shall be market-driven and applicable in heterogeneous geographical, social environments and under various economic conditions. Planning and operational coordination, and flexibility mechanisms shall be primarily market-based, with appropriate market signals and incentives. Regulatory, administrative and governance design shall facilitate these market-driven interactions. Design, development and test of adequate incentives shall be performed to maximise the welfare of the energy transition. The operational and planning arrangements between TSOs and DSOs need to be revised and developed further in order to support a market framework that unlocks the potential of prosumers. Resources should be enabled to value their potential in the most efficient way.

Throughout the market-driven interactions, data will need to be managed in an efficient and transparent way, while respecting competition laws, confidentiality laws and the privacy of prosumers, and allowing adequate access to ensure that prosumers are active in the market.

Finally, the market-driven interactions shall be designed, developed and tested having in mind a cross-sectorial approach in order to facilitate an effective and efficient integrated energy system.

PPC 2.1: Market models and architecture for TSO-DSO- System User interactions (IP 2022-2025)

Scope of PPC: Definition of suitable market models for the interaction of TSOs and DSOs, to central and local markets and their users and across different time frames. Identification of technical, market and business barriers to the smooth cooperation and interaction between TSOs, DSO and prosumers. Provide evidence related to the benefits of market-driven options and solutions. Interfaces definition and specification between different actors.

- According to the Project Evaluation Report (Annex II) PPC 2.1 has not been sufficiently covered by the completed and on-going projects
- According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC requires some additional funding

PPC 2.2: Control and operation for enhanced TSO-DSO- System User interactions (IP 2022-2025)

Scope of PPC: Design, development and demonstration of effective control mechanisms and technologies for prosumers participation in the market. Optimisation of the operation of the energy system and the provision of Ancillary Services from distributed resources, ensuring resilience contributions from DER. Real time balancing and management of flexibility.

- According to the Project Evaluation Report (Annex II) PPC 2.2 has not been sufficiently covered by the completed and on-going projects
- According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC was not adequately funded.

PPC 2.3: Platform Development for TSO-DSO cooperation (IP 2022-2025)

Scope of PPC: Design and development of platforms for an effective secure and governed information sharing, allowing access and cooperation from multiple energy system players and an efficient organisation of the energy system. Identify what data and how it is exchanged between the system operators, for each service (e.g., balancing, controlled islanding, congestion management and voltage control, reactive power, dynamic voltage control, etc).

- According to the Project Evaluation Report (Annex II) PPC 2.3 has not been sufficiently covered by the completed and on-going projects
- According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC was not adequately funded.

PPC 2.4: Planning tools for TSO-DSO cooperation (IP 2022-2025)

Scope of PPC: Optimisation of the energy system planning and its implications on capital investments. Expand the more developed TSO- DSO cooperation at operational level and time-frame towards the network planning longer time-frame. Clarify how the planning tasks are coordinated, in order to contribute to an efficient digitalisation of the entire electricity grid.

- According to the Project Evaluation Report (Annex II) PPC 2.4 has not been sufficiently covered by the completed and on-going projects
- According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC has been already well funded.

PPC 2.5: Develop a Digital Twin of the European Electricity Grid (IP 2025+)

The creation of a digital twin will build on initial pilot innovation projects already started or being prepared for in 2023 and be achieved through coordinated investments in five areas: (i) observability and controllability; (ii) efficient infrastructure and network planning; (iii) operations and simulations for a more resilient grid and improved security of supply; (iv) active system management and forecasting to support flexibility and demand response; and (v) data exchange between TSOs and DSOs.PPC 2.6: Viable business cases through market mechanisms and incentives (IP 2025+)

Scope of PPC: Design, test and demonstrate market mechanisms and incentives for an open participation of (aggregated) prosumers (system users) and effective cooperation of system operators ensuring viable business cases and positive cost benefit analysis in a sector coupling context. Perform cost-benefit analysis of different options for coordination schemes.

PPC 2.7: Governance for TSO, DSO and System Users (IP 2025+)

Scope of PPC: Enhancing the regulatory and administrative framework for an effective and efficient Energy System Governance. Develop and demonstrate enhanced and robust standards for cooperation and coordination among energy system players. Leverage the use of standards for data exchange of data. Definition of appropriate data models that can represent properly all the TSO-DSO-System User interactions.

HLUC 3: Pan European Wholesale Markets, Regional and Local Markets

There is a clear need to design a radically new multi-energy market that would include cross-energy sector coupling, covering all temporal scales (from seconds, minutes, hours, days, months and years) and spatial granularity (from local district to regional and international areas), which will be critical for cost effective transition to a low carbon energy future, with energy supply based on increasing amount of renewable generation and decarbonisation of demand sectors (transport, heating, cooling, industry)

In this context, emerging flexibility technologies and advanced control systems in all energy sectors (electricity, heating and cooling, Gas, transport, hydrogen, etc), would deliver major cost savings, that the new market design needs to address, including:

- savings in system operating costs by the avoided curtailment of zero-carbon renewable generation and providing significantly more cost-efficient provision of the required balancing services across all energy sectors (energy trading and balancing services market)
- savings in capital expenses associated with reinforcing distribution, transmission network assets (gas/hydrogen and electricity) driven by reduced peak demand levels and the cost-effective management of network constraints (market for network congestion management)
- savings in capital expenses associated with investments in conventional generation, driven by reduced peak demands and support by interconnection (capacity market)
- savings in capital expenses associated with investments in low-carbon generation while meeting the carbon targets, driven by the much more efficient utilisation of lower-cost variable renewable generation (low carbon generation market)
- In this context the new legislation asks for enhanced roles of DSOs, particularly in procurement of ancillary services, flexibility, data man- agement, effective integration of heat and transport sectors. Markets must encourage development of flexible technologies and control systems and Member States must eliminate obstacles to market-based pricing. Bidding zones must be reviewed by TSOs, and possible alternative concepts should be proposed. DSOs should align network access and congestion tariffs and charges. Member States should enable scarcity pricing, interconnection, DSR and storage to contribute to capacity market.

PPC 3.1: Fundamental market design (IP 2022-2025)

Scope of PPC: Development of fundamentally new, multi-energy market with appropriate temporal and spatial granularity to facilitate cost effective transition to low carbon energy future, considering energy balancing, network congestion management services, EU wide capacity market, renewable power purchase agreement. Development of cost effective market mechanism for allocation of costs related to the provision of balancing services, network charging, investment in conventional and low carbon generation and would recognise option value of flexibility technologies dealing with uncertainties in future deployment of low carbon technologies.

- According to the Project Evaluation Report (Annex II) PPC 3.1 has been covered to a certain extent by the completed and on-going projects, more R&I efforts are needed.
- According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC was not adequately funded.

PPC 3.2: Regulatory framework and strategic investments (IP 2022-2025)

Scope of PPC: Development of new regulatory frameworks that would enable development of new security of supply standards, for supporting cost effective delivery of security and resilience of supply from local to national / international level (dealing with high-impact low probability events) and that would support strategic investment in energy infrastructure when/where appropriate.

- According to the Project Evaluation Report (Annex II) PPC 3.2 has not been sufficiently covered by the completed and on-going projects.
- According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC was not adequately funded.

PPC 3.3: IT systems for cross-border trading (IP 2022- 2025)

Scope of PPC: Demonstration of platforms /IT systems for market-based trading of energy, balancing services across interconnectors and supporting EU wide capacity market and for enhancing security and resilience of supply of multi-energy systems

- According to the Project Evaluation Report (Annex II) PPC 3.3 has been covered to a certain extent by the completed and on-going projects, more R&I efforts are needed.
- According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC was not adequately funded.

PPC 3.4: Validation of new market concepts (IP 2025+)

Scope of PPC: Development and demonstration of advanced technologies and control concepts /platform tools for supporting multi-energy systems market based on appropriate data exchange between different energy sectors in local, national and international regions and supporting decentralised, peer-to-peer trading, (enabling end consumers to trade energy and ancillary services in real time), while supporting market driven system control (e.g. congestion management) and assess the impact on end consumers services quality.

PPC 3.5: IT systems for TSO/DSO control to support real time balancing (IP 2026+)

Scope of PPC: Demonstration of platforms /IT systems for market driven coordination of trading of energy, balancing services and network congestion management. Demonstration of advanced platforms for coordination of trading of energy, balancing services and network congestion management considering local, national and international level.

HLUC 4: Massive Penetration of RES into the transmission and distribution grid

The EC has set very ambitious targets for RES penetration in the European Energy System. This is a key element of both the EU Green Deal package and the Fit for 55 proposals. Furthermore, it is also part of the REPowerEU ambition to reduce the European dependency on imported energy. In order for this ambition to be successful, significant developments are required of both large, centralised RES installations at Transmission level and distributed RES at both Transmission and Distribution levels. The massive penetration of RES stresses the power grids at multiple levels.

On one side, the operation with less mechanical inertia and with increased imbalances between generation and load, reinforcing the importance of improved forecast, where sophisticated analytics can play a key role. Still on the technical side, adequate protection mechanisms and controls for grid stability must be in place. Furthermore, adequate global monitoring systems need to be installed to anticipate and correct system stresses.

The integration of higher levels of RES must also be considered in the context of more DC connections from UHV level (embedded interconnections) downwards to Power Electronics connected devices (see also HLUC 6), raising the need of extensive grid-forming capabilities and evoluted control of such devices.

On the other side, market dynamics and new market designs must ensure participation and guarantee a well-functioning market also in the future situation of predominant zero-variable-costs generation. Furthermore, as also reinforced in the recent REPowerEU communication by the European Commission, reduced risk exposure for vulnerable consumers must be taken into account in such designs.

Energy System resilience shall be assured in the context of a massive RES penetration, counting with the contribution of storage and flexibility solutions. Indeed, with the expected increase of sectors integration and maturity of a multi-energy vectors system of systems, with the corresponding storage and flexibility capabilities, the scenarios, the ability to integrate higher levels of renewables and whole system behaviour need to be revisited to ensure an effective and efficient functioning.

An important part of the increased penetration of RES would be utility-scale wind and solar PV projects for which completion dates could be brought forward by tackling delays with permitting. This includes clarifying and simplifying responsibilities among various permitting bodies, building up administrative capacity, setting clear deadlines for the permitting process, and digitalising applications.

PPC 4.1: Technical barriers and technical measures for integration of RES at multiple levels and sectors (IP 2022-2025)

Scope of PPC: Creating the conditions for the effective participation of industrial, residential actors and energy communities and for deploying corresponding grids leading to an increased share of RES in the energy system; ensure the digital capabilities for enabling more players being able to be present in the energy system and in the energy markets

- According to the Project Evaluation Report (Annex II) PPC 4.1 has not been sufficiently covered by the completed and on-going projects.
- According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC has been already well funded.

PPC 4.2: Control and operation tools for a RES based energy system (IP 2022-2025)

Scope of PPC: Design and test advanced technologies and control mechanisms for integrating massive volumes of RES at distribution and transmission level, handling network constraints and providing flexibility needs, ensuring coordination across voltage levels and energy sectors. Design and test of Virtual Power Plant (VPP) solutions and hybrid power stations, design solutions for renewable energy generation technology to be able to contribute to system flexibility, stability and congestion management, investigate implications in protection and control.

- According to the Project Evaluation Report (Annex II) PPC 4.2 has been sufficiently covered by the completed and on-going projects

- According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC was not adequately funded.

PPC 4.3: Infrastructure requirements and network technologies as solutions for integration of massive RES (IP 2022-2025)

Scope of PPC: Ensure the integration of massive RES at multiple voltage levels through advanced grid solutions (e.g., HVDC, FACTS) and increasing flexibility capabilities from RES. Ensure the efficient and reliable grid-connection and system-integration of large RES generation (e.g., large offshore grids) and multiple microgrids connected to the distribution grid. Resilience and cybersecurity risks in the renewable energy and grid supply chain, including offshore wind.

- According to the Project Evaluation Report (Annex II) PPC 1.3 has been covered to a certain extent by the completed and on-going projects, more R&I efforts are needed.
- According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC has been already well funded.

PPC 4.4: Planning for a resilient system with massive penetration of RES (IP 2022-2025)

Scope of PPC: Enhance system resilience in the presence of increased RES penetration at all levels, via situational awareness, advanced forecasting methods, restoration mechanisms, adaptive network reconfiguration including microgrids and smart load shedding ensuring stability of the system and robustness to extreme events; Planning should take into consideration the integration of other energy carriers (e.g. hydrogen) and sectors (e.g. mobility).

- According to the Project Evaluation Report (Annex II) PPC 1.3 has been covered to a certain extent by the completed and on-going projects, more R&I efforts are needed.
- According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC has been already well funded.

PPC 4.5: Well-functioning markets for a RES based energy system (IP 2025+)

Scope of PPC: Ensure appropriate mechanisms for market participation from RES at multiple levels, from local to global scale, and from heterogeneous energy sectors, ensuring viable business cases and backed by supporting regulations; Ensure reduced risk for vulnerable consumers under a market design with massive penetration of renewables; ensure market mechanisms are transparent and non-discriminatory.

PPC 4.6: Policies and governance for a RES based energy system (IP 2025+)

Scope of PPC: Develop tools and mechanisms to ensure the governance of top-down RES targets with bottom-up private investments in RES, storage and flexibility means; ensure temporal match in the evolution trajectories of RES plants, grids developments, and sector coupling and ensure adequacy at various time frames (season, year, multiple years) through most appropriate mechanism (capacity market, variable capacity subscription, non-wire solutions)

HLUC 5: One stop shop and Digital Technologies for market participation of consumers (citizens) at the centre

Consumers - also in the role of prosumers – and citizens have a critical proactive role to play to accelerate the adoptions of new energy services and technologies in their environment as well as for deciding the most suitable options for them to reach the decarbonisation objectives set through the high-level policies. The pace of consumer adoptions will significantly impact the design of Cross sectorial Energy System infrastructures with the acceleration of electrification – particularly to accommodate new heat pumps and electrical vehicle home charging as well as the introduction of new decarbonised heat network and Green Hydrogen in specific sectors. Education and training is a fundamental aspect of this HLUC as consumers buy energy for their daily and seasonal needs (having light in their homes, E-Vehicles for moving around, heating pumps to have warm homes, ovens for cooking, batteries for computers, smart phones which need to be loaded, etc). Integrated Energy System Complexity is and will be hidden and citizens must not be requested to become all engineers. Their needs will, however, change. Consumer needs will also evolve with different renewable energy carriers (such as hydrogen). System adoptions for the cross sectorial efficient integration require an energy system evolution beyond electricity over time. While local solutions may differ country by country, it is necessary that the differences are transparent to the consumers and citizens. IT solutions are needed that facilitate consumer/citizen inclusions and that are independent or abstract from the contingencies of a specific market.

Furthermore, it is necessary to integrate the energy system in the wider picture of the data economy so that consumer/citizen inclusion means also to facilitate use cases that go beyond energy and cross-link to completely new domains.

This HLUC will develop the necessary research and innovation to facilitate one stop shop consumer/citizen participation in the energy system and, correspondingly, inclusion of the energy system in the concept of data economy. This implies several aspects: standard interfaces, communication solutions and better secure communication solutions.

The transformation to the distributed, renewable energy future demands the paradigm shift from supply side response to demand side response. Consumer behaviour has an impact on the EU decarbonisation targets. They can contribute to system flexibility and renewable consumption. Not by manual intervention but with the help of digital enabled energy management of microgrids in customer premises.

PPC 5.1 Value of Consumer/Customer acceptance and engagement (IP 2025+)

Scope of PPC: Analysis of the platform requirements in order to accelerate the adoption of new energy services and technologies. The access to data and energy services will allow the consumer/customer to go beyond the electricity sector into a fully integrated energy system. Educational aspects and training needs for consumers must be considered within the analysis so to ensure the widest access to the platform.

- According to the Project Evaluation Report (Annex II) PPC 5.1 has not been sufficiently covered by the completed and on-going projects
- According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC has been already well funded.

PPC 5.2: Plug and play devices and IoT (Internet of things) including security by design (IP 2025+)

Scope of PPC: One of the obstacles for consumers to have a more active role in the energy system is the lack of solutions that really support plug and play. Purpose of this PPC is to remove this barrier and develop solutions that facilitate joining any kind of energy market across Europe. Particular emphasis will be placed in promoting interoperability for energy-smart appliances to their participation in demand response schemes. Also special care must be taken to enhance smart meters connectivity trending to the real time domain as this will be more and more requested by flexibility opportunities.

- According to the Project Evaluation Report (Annex II) PPC 5.2 has not been sufficiently covered by the completed and on-going projects
- According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC has been already well funded.

PPC 5.3: Utilisation of Communication Networks including cyber security (IP 2022-2025)

Scope of PPC: Smart solutions will use a variety of connection solutions. It is critical to facilitate connection while preserving security. This PPC will investigate how security by design can support use of communication networks, including private ones, in energy applications.

- According to the Project Evaluation Report (Annex II) PPC 5.3 has been covered to a certain extent by the completed and on-going projects, more R&I efforts are needed.
- According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC was not adequately funded.

PPC 5.4: Cross-sectorial flexibility use cases (IP 2022-2025)

Scope of PPC: Redefine access to flexibility by means of use cases that do not target directly energy flexibility but bring flexibility as consequence, in order to attract citizens. Examples can be given by the idea of selling comfort instead of heating, other ideas can emerge from other business sectors such as security or health.

- According to the Project Evaluation Report (Annex II) PPC 5.4 has not been sufficiently covered by the completed and on-going projects
- According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC requires some additional funding.

PPC 5.5: Data Spaces (IP 2025+)

Scope of PPC: Considering current developments in the Energy Data Space field, promote the development and validation of de-centralised and federated data spaces, addressing on the one hand the data management needs of each of the stakeholder involved in the energy system value chain and on the other hand, safeguarding data security and sovereignty. Focus on the development of federated data sharing mechanisms (utilising suitable and "green" Distributed Ledger Technologies) and associated business models that facilitate both economic and non-economic transactions between data owners/ providers and data consumers, while exploring objective data valuation models to avoid deterministic and non-realistic fee requests for shareable data assets.

PPC 5.6: Building skills needed for developers and users of the energy system to accelerate its transition through its digitalisation (IP 2025+)

Scope of PPC: Develop and Preparation of guidelines for the development of digital skills in energy as needed by the industry and users. An analysis of digital skills gaps, between what is demanded and what is offered, has to be done and continuously updated Educational frameworks will target program not only for Universities but also practicing for engineers, technicians and installers in the whole energy domain. Also, users of the energy system have to be a target for training and skilling. These projects are at a Coordination, Support Action (CSA) level.

PPC 5.7: Service management and operations (IP 2025+)

Scope of PPC: Design of adequate Service Management. Digitalise the energy system and processes based on new business models, new revenue streams and value producing opportunities: Setup appropriate service management processes, systems and organisations that meet demand for superior customer service and deals with strong competition. These projects are at a Innovation Action (IA) level.

PPC 5.8: Sharing IT infrastructure investments (IP 2025+)

Scope of PPC: Use IT infrastructure actively by more than one actors in the energy domain. Develop new business models and processes by digitalization the energy system. Develop new business models, new revenue streams and values producing opportunities. Create the right incentives to develop advanced communication infrastructures: Identify such infrastructure and propose a fair funding scheme for the involved actors. These projects are at a Coordination, Support Action (CSA) level.

PPC 5.9: Large Scale Demonstration activities (IP 2026+)

Scope of PPC: This PPC should take the results of the PPCs 5.1-5.5 and bring them to a new scale by large demonstrators. For example, develop an experimentation platform to test and simulate energy communities in combination with innovative activities such as blockchain-based energy trading.

PPC 5.10: Creating consensus on consumer solutions (IP 2026+)

Scope of PPC: Transfer the results of all the PPCs from innovation to real life by preparing the conditions for new standards in particular at the level of software API's and in terms of service definitions.

HLUC 6: Secure operation of widespread use of power electronics at all systems levels

Power electronics driven components are becoming a key asset for modern power grids, but there is not yet a clear understanding of how these devices will shape system operation. The more the share of power electronics devices grows, the more there is a need to involve these devices with an active role. This is true at different levels for the grid. Projects considering the transmission system shall consider the evolution of HVDC towards multi-terminal multi-vendors meshed DC grids. These are appearing first of all for off-shore RES applications, but are expected to spread also in on-shore solutions and to move from HV also to MV applications. In particular, the definition of the roles of grid-forming converters is still mostly at research level and a flexible transition between different modes of operation shall be further investigated, including how substations with traditional transformers can be enhanced by power-electronics and how the penetration of smart power routing devices such as FACTS and Solid-State Transformers can be applied.

This HLUC will explore the role of the power electronic devices at every level from the transmission to the LV distribution and prepare the condition for a system level operation that is fully capable of using the control capability of power electronics. The overarching goal is to facilitate a power electronics dominated grid.

PPC 6.1: Control solutions for next generation PV and battery inverters (IP 2022-2025)

Scope of PPC: This PPC will develop control solutions for components such as PV and Battery inverters that can be considered grid friendly,i.e. able to provide a variety of services that can be used at system level. The goal is the facilitation of digitalised plug & play solutions.

- According to the Project Evaluation Report (Annex II) PPC 6.1 has not been sufficiently covered by the completed and on-going projects.
- According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC requires some additional funding.

PPC 6.2: Hybrid transmission/distribution and hybrid distribution AC/DC grids (IP 2022-2025)

Scope of PPC: This PPC will develop the necessary control solution that support the development of hybrid AC/DC grids in HV and MV. Goal is not to focus on new topology but on the development of the proper concepts that support interoperability and cooperation between converters operating in the DC and in the AC section of the system.

- According to the Project Evaluation Report (Annex II) PPC 6.2 has been covered to a certain extent by the completed and on-going projects, more R&I efforts are needed.
- According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC has been already well funded.

PPC 6.3: Next generation distribution substation (IP 2022-2025)

Scope of PPC: This PPC will explore all the possible integration of power electronics in the substation or close to the substation to develop the concept of a flexible and programmable power grid in which the substation is a center of intelligence that facilitate the optimal power routing while ensuring power grid resilience.

- According to the Project Evaluation Report (Annex II) PPC 6.3 has not been sufficiently covered by the completed and on-going projects.
- According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC was not adequately funded.

PPC 6.4: Simulation methods and digital twins at distribution and transmission level for power electronics driven networks (IP 2022-2025)

Scope of PPC: The growing presence of power electronics is radically modifying the dynamics of the power grids. This PPC will tackle the need of the new simulation tools that go beyond the classical separation between phasor simulation and electromagnetic transient analysis.

- According to the Project Evaluation Report (Annex II) PPC 6.4 has not been sufficiently covered by the completed and on-going projects.
- According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC has been already well funded.

PPC 6.5: HVDC interoperability, multi-terminal configurations, meshed grids (IP 2026+)

Scope of PPC: As mentioned in the CIGRE Green Book, the goal of multi-terminal DC transmission systems is to keep the main advantages of point-to-point DC transmission networks and to maximise the utilisation of the assets. Multi-terminal configurations will improve the investment on assets and the environmental impact of the power system infrastructure. The goal of this PPC is the development of the necessary methodologies, tools and models for the analysis of the operation of such configurations.

PPC 6.6: Large Scale Demonstration activities (IP 2026+)

Scope of PPC: This PPC shall take the results of the PPCs 6.1-6.5 and bring them to a new scale by large demonstrators.

PPC 6.7: Standardisation activities (IP 2026+)

Scope of PPC: Transfer the results of all the PPCs of this HLUC from innovation to real life preparing the condition for new standards and grid codes compatible with the results of the projects. These projects are at a Coordination, Support Action (CSA) level.

HLUC 7: Enhance System Supervision and Control including Cyber Security

The growing electrification and the more decentralised deployment of renewable power generation will require reinforced and smarter electricity networks, able to accommodate both centralised and decentralised elements and to make the best of RES allocation over the European territory. Pervasive network Digitalisation, supported by high-capacity cyber-secure communication networks, will ensure decentralised monitoring and control. Not only density of the network, but also interconnection capacities –with harmonised security, planning and operation standards- will be needed to match growing RES supply and electricity demand over larger areas, as well as transparency to market participants all over Europe. These changes are calling for a complete reconsideration of the concept of control room both at TSO and DSO level. The change will affect not only the definition of the appropriate HLUCs but also the fundamentals of the architectures. While we can still imagine the control room as a centralised place, the intelligence will be more distributed and, for the case of distribution grids, mostly at the edge.

As in most of the cases there are existing “legacy systems”, where not only hardware and software but data base contrasted and updated are fundamental to keep the operation of the system, the transition to the new required architectures should be well planned, checked and implemented in a secure way. This will be referred from now on as the “transition from legacy systems”.

At the same time with introducing significant changes in the concept of operation, there will be a significant impact on the workforce. This impact can be manifested in two directions: needs of new types of Human Machine Interface and need of training to prepare the workforce to operate under the modified conditions.

PPC 7.1: Next Generation of TSO control room (IP 2022-2025)

Scope of PPC: System level automation to cope with the distributed characteristics of the generation and the active role of the loads. Define new architecture and solutions for the control room of the future. Coordinate work with PPC 7.2 for a coherent TSO-DSO cooperation.

- According to the Project Evaluation Report (Annex II) PPC 7.1 has not been sufficiently covered by the completed and on-going projects.
- According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC requires some additional funding.

PPC 7.2: Next generation of DMS (Distribution Management Systems (IP 2022-2025)

Scope of PPC: Design new architecture of the Advanced DMS to consider new DER integration services and interfaces with both IT and OT solutions. Investigate new architectures and services for the DSO. Coordinate work with PPC 7.1 for a coherent TSO-DSO cooperation.

- According to the Project Evaluation Report (Annex II) PPC 7.2 has not been sufficiently covered by the completed and on-going projects.
- According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC was not adequately funded.

PPC 7.3: Next generation of measurements and GIS for distribution grids (IP 2022-2025)

Scope of PPC: Investigate data fusion, as one of the key topics in the process of digitalisation of power grids. Investigate new types of data associated to new measurement devices and other sources of information, such as GIS (Geographic Information System) to improve planning and operation of distribution grids. Also special care must be taken to enhance smart meters connectivity trending to the real time domain as this will be more and more requested by flexibility opportunities.

- According to the Project Evaluation Report (Annex II) PPC 7.3 has been covered to a certain extent by the completed and on-going projects, more R&I efforts are needed.
- According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC was not adequately funded.

PPC 7.4: Wide area monitoring, control and protections (IP 2022-2025)

Scope of PPC: Investigate in depth the potential of Phasor Measurement Units as a key measurement tool both at transmission and distribution level, the application in monitoring, control and protection that fully exploit the capability of the Wide Area approach.

- According to the Project Evaluation Report (Annex II) PPC 7.4 has not been sufficiently covered by the completed and on-going projects.
- According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC was not adequately funded.

PPC 7.5: Grid operator of the future (IP 2025+)

Scope of PPC: Prepare the next generation of control room operators to deal with changing solutions and tools for grid operation. Cybersecurity challenges and countermeasures are fundamental. Define educational needs and solutions for the personnel that will work in the control room of the future in cooperation with 7.1-3.

PPC 7.6 Grid field workforce of the future (IP 2025+)

Scope of PPC: Prepare the field workforce to handle many more electronic devices (hardware and software), each with cybersecurity challenges and countermeasures, where needed. Distribution grids with a high number of DERs (different ownership than the network operator) and an increasing intervention of distributed control (i.e. cloud computing) require special attention.

PPC 7.7: Human machine interface (HMI) (IP 2025+)

Scope of PPC: Design effective ways to present data to the operator and the way the HMI drives the possibility of interaction of the operator, as the automation level grows and more data becomes available. There will be a clear trend to distribute control allowing automatic actions in the network that must be well supervised and controlled in a coordinated way by the control room operator(s).

PPC 7.8: Cybersecurity of Energy Networks (IP 2025+)

Scope of the PPC: Identify the specific ICT services, systems or products that might be subjected to coordinated risk assessments with priority, including risks in the renewable energy, e.g. offshore wind and grid supply chain. Both the electricity and gas and hydrogen networks will be considered. The outcomes of the PPC should consider the current and the future Directives on cyber security.

PPC 7.9: Large scale demonstration activities (IP 2026+)

Scope of PPC: This PPC shall take the results of the PPCs 7.1-7.3 and bring them to a new scale for higher impacts by large demonstrators.

PPC 7.10: Standardisation activities (IP 2026+)

Scope of PPC: Transfer the results of all the PPCs 7.1-7.7 from innovation to real life preparing the condition for new standards and architectures compatible with the results of the projects.

HLUC 8: Transportation Integration & Storage

The 2016 EU "Low-emissions mobility strategy" and the 2020 "Sustainable and Smart Mobility Strategy" have shown that an integrated system approach is required to put the transport sector on a sustainable path. Central elements of such an approach include actions on overall vehicle efficiency, promoting low- and zero emission vehicles and the long-term evolution to low- and zero-carbon electricity system. This entails alternative and net-zero- carbon fuels for transport, together with multi- modal integration that shifts towards more sustainable transport modes of holistic operation. Conditions must ensure the effective deployment of publicly accessible and private recharging points for all types of electric vehicles and the smart efficient integration of vehicle charging infrastructure into the electricity system.

With the focus on system implications, different transport sectors will be considered, including:

Road transport: including (a) micro mobility (e-bikes, e-scooters), (b) private vehicles, (c) taxies and fleet vehicles, (d) buses (e) lorries

Railway transport: Trains

Waterborne transport: River and sea boats

Airborne transport: commercial and passenger airplanes

In the context of fuel/energy used, low carbon sources could be electricity and lower carbon fuels (biofuels, hydrogen, ammonia) including a combination of electricity and fuels (hybrid technologies).

The challenge of EV charging in its broader perspective is to be an active component of the integrated grid utilising the fundamental characteristics of the on-board battery for achieving optimal solutions for the benefit of the end users and improving the carbon footprint of e-mobility. Inevitably, such an approach will require charging modes that meet the needs of the user on the one hand but are aligned with the interconnected system capabilities calling for smart charging solutions (as opposed to direct and immediate charging from the moment the vehicle is plugged in to the charging point).

This need is primarily dictated by the user's needs, leading to low system cost solutions that will enhance the advantages of BEVs as opposed to other forms of transport. R&I needs in this field are of high priority and timely, since optimal operation of the interconnected systems requires the active contribution of the connected EVs following modes that do not violate the comfort needs of end users and, at the same time, achieve low-cost solutions that will guarantee an affordable mobility, contributing to enhance BEV penetration and to support the energy transition objectives.

Adopting smart charging solutions can lead to dynamic load management which is a pivotal concept to create customer benefits from the intelligent recharging of EVs. Smart charging has the ability to automatically distribute the available power between the charging points and the electric vehicles that are being charged simultaneously. In consequence, through such advanced systems, energy flows can be effectively managed in order to have a positive effect in the use of local resources. This will lead to an integrated grid capable of smoothing peaks and maximising the use of the developed smart infrastructure serving all connected users through optimal energy prices for the benefit of the end users.

Hence, as opposed to traditional blind charging, smart charging allows to exchange information, allowing monitoring and management of the energy consumption. As a result, smart charging strategies can lead to the following advantages:

- improved utilisation factor of low or high-power charging infrastructures,
- decrease the need for investments for grid reinforcement by a factor of two compared to a situation with no smart charging and, hence, increasing the number of BEVs charged from the same infrastructure,
- generate tradeable flexibility to the grid, offering tangible benefits to the users (in terms of cost reductions and ease of charging) since they are the providers of the flexibility,
- reduce the prospective peak load for the generation plant and grid by up to 25%, which can lead to improved utilisation rates of the electricity distribution infrastructure and additionally improve the stability of the integrated grid.
- The assessment of the role and value of alternative approaches for the transport sector decarbonisation should be the focus of this work, considering the impact on the future energy system operation and design and benefits of achieving cost effective transition to zero carbon energy future, as the interface between transport and energy sectors is the crucial element for ensuring the successful development for both.

PPC 8.1: Technical and economic implication of decarbonisation of transport sector (IP 2022-2025)

Scope of PPC: Development of alternative decarbonisation strategies for transport sectors (electricity and hydrogen based) for (a) micro-mobility, public, fleet and private vehicles, (b) long-on the ground transport (c) riverboats, sea-boats, (d) aviation. Assess alternative funding policy strategies for decarbonisation of different transport sectors. Assess the the impact on investment cost of conventional and low carbon generation, network infrastructure reinforcement and system operating costs and the system value of smart electro mobility in providing control services.

- According to the Project Evaluation Report (Annex II) PPC 8.1 has not been sufficiently covered by the completed and on-going projects.
- According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC has been already well funded.

PPC 8.2: Enhancing effectiveness of energy system operation and resilience with electromobility (IP 2022- 2025)

Scope of PPC: Assessment of the benefits of smart control of different charging infrastructures in providing various system services through connecting EVs to IoT concept. Incorporation of uncertainties related to the provision of services by transport sector, specifically considering V2G from private, fleet and public vehicles. Assessment of the V2X based enhancement of resilience of supply and the benefits of fast-charging stations in providing security services.

- According to the Project Evaluation Report (Annex II) PPC 8.2 has been covered to a certain extent by the completed and on-going projects, more R&I efforts are needed.
- According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC was not adequately funded.

PPC 8.3: Integrated planning of energy and transport sectors (IP 2025+)

Scope of PPC: Development of probabilistic system planning strategies incorporating the impact of large- scale deployment of different transport sector and energy storage technologies. Develop common standards, protocols and digital services for full interoperability between energy and transport sectors, allowing seamless connectivity of EVs to IoT. Development of electricity system design codes to include the secure contribution of smart charging of EVs and V2G, practices, considering solutions for slow and rapid charging infrastructures. Planning for Battery efficient recycling and health preservation.

PPC 8.4: Adapting policy and market for seamless cost-effective merging of transport and energy sectors (IP 2025+)

Scope of PPC: Development of appropriate market design to enable smart connectivity and use of the energy system through responsive charging infrastructure. Modify regulatory framework to enhance TSO–DSO interaction in supporting cost effective solutions for the transport sector. Provide evidence for the required changes in the design of the energy market to provide appropriate costs/ revenues related to the operation of the charging infrastructure (e.g. establishment of electro-mobility market for system services).

PPC 8.5: Demonstration activities (IP 2026+)

Scope of PPC: Development of appropriate IT infrastructure for common management of charging stations supported by appropriate market design to enable information exchange between energy system and charging point operators. Demonstrate V2G operability in terms of the speed of discharging and measurements /signals needed for provision of frequency regulation and grid stability services.

HLUC 9: Flexibility provision by Building, Districts and Industrial Processes

The recent Clean Energy legislation requires that renewable heating and cooling must contribute to the progressive increase of the share of renewable energy and contribute substantially to the efficient use of available resources. Provisions are expected to be included, at national, regional and local level, for the integration and deployment of renewable energy, including for renewables self-consumption with the parallel growth of renewable energy communities. The effective use of unavoidable waste heat and cold when planning, including early spatial planning, designing, building and renovating urban infrastructure, industrial, commercial or residential areas. Additionally, effective use should be made of the renovation and development of energy infrastructure, including electricity, district heating and cooling, natural gas and alternative fuel networks.

Furthermore, extrapolating from the building level to a wider neighbourhood, campuses and community level (and even smart city level), provisions should be included to allow an efficient and effective integration of smart communities in the energy system, addressing smart grid connectivity issues, market participation issues, advance control mechanisms capable of preserving and enriching resilience.

Finally, the integration of the heating and cooling sector with the integrated grid is still limited. Rules for effective participation in the market are incipient. Initial control mechanisms and technologies for allowing such sector-coupling integration exist but need further development. Understanding of behaviour and impact of buildings, infrastructure and communities in the grids and markets need further analysis and demonstration. Data management and cybersecurity issues still need further development to enhance smartness, responsiveness, security and resilience of all interconnected active resources in the integrated grid.

PPC 9.1: Value assessment of the integration of buildings, infrastructure and smart communities in a RES based energy system (IP 2022-2025)

Scope of PPC: Creating the conditions for the effective integration of renewable generation from multiple sectors in buildings and other individual or aggregated infrastructures leading to an increased share of RES in the energy system supported by digitalisation.

- According to the Project Evaluation Report (Annex II) PPC 9.1 has been covered to a certain extent by the completed and on-going projects, more R&I efforts are needed.
- According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC has been already well funded.

PPC 9.2: Control and operation tools for the integration of buildings and smart communities (IP 2022-2025)

Scope of PPC: Design and test advanced control methods and enabling technologies to integrate multi-sector generation, ensuring the needed flexibility from individual or aggregated heating and cooling devices, buildings, local communities, benefiting from energy system digitalisation. Demonstrate effective and efficient management (e.g., via HEMS and BMS) of connected and stand-alone buildings, living quarters, businesses and industries, communities supplied by RES.

- According to the Project Evaluation Report (Annex II) PPC 9.2 has been covered to a certain extent by the completed and on-going projects, more R&I efforts are needed.
- According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC has been already well funded.

PPC 9.3: Planning for reliable integration of buildings and infrastructures in an integrated energy system (IP 2022-2025)

Scope of PPC: Design and validate energy models connecting in a digitised electricity grid multi-vector systems supplying buildings, infrastructures and communities, through enhanced forecasting and multi-objective techniques to achieve optimal use of resources. Ensure secure and resilient integration of multiple infrastructures, forming microgrids, VPPs and VPSs, offering overall grid stability at the lowest cost.

- According to the Project Evaluation Report (Annex II) PPC 9.3 has not been sufficiently covered by the completed and on-going projects.
- According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC has been already well funded.

PPC 9.4: Governance for an effective integration of buildings and smart energy communities (IP 2025+)

Scope of PPC: Development of solutions of designing, setting up and operating active energy buildings and communities that will offer optimal solutions to the tenants, users and the community as an entity. The deployed practices and systems will cover design and use of appropriate smart technologies and systems and develop appropriate codes, standards and regulations for coordination mechanisms with system operators and multiple energy stakeholders. Identify best practice governance options for buildings and energy communities.

PPC 9.5: Evolved markets for enabling buildings and energy community facilities actively participating in support of the energy transition (IP 2026+)

Scope of PPC: Ensure appropriate mechanisms for market participation of buildings and infrastructures with multi-vector RES sources (e.g., low carbon gas-fired, biomass CHP units), making use of digitally enabling smart technologies, to actively participate offering viable business cases that they are capable of, including the provision of ancillary services at different aggregation levels.

4

The ETIP SNET R&I Implementation Plan 2025+ (NEW PPCs not defined before)

This section provides the description of the **new** Priority Project Concepts (i.e. PPCs not yet defined and described with enough details in the previous ETIP SNET IP 2022-2025) to be implemented during this R&I Implementation Plan 2025+ with R&I Projects running during the period 2025-2028. The descriptions have the following sections:

- Type of PPC Action (IA/RIA)
- PPC Start/End Year
- Indicative PPC Budget
- Expected PPC Outcome
- Scope of PPC

PPC 1.4: Integrating hydrogen and CO2-neutral gases

Type of Action: RIA	TRL
Start/End Year: 2024-2029	Indicative Budget: 25 M€

EXPECTED OUTCOME

- Enhanced monitoring of the future hydrogen market and their interactions with the electricity market and EU emission trading system;
- (HLUC 2) Reduced volatility of the electricity markets in periods of shortage of renewable generation;
- Reduced consumption of natural gas and reduction of CO2 emissions
- Help industrial companies and generation companies in meeting their CO2 emission trading targets;
- Increased the overall reliability and adequacy of the generation system and thus contributing to the increase on security of supply, while decarbonising the generation portfolio;
- Developed advanced monitoring and control systems to operate natural gas grids with large incorporation of renewable gases while keeping quality of supply to the final end gas consumers;
- Optimised operation of industrial compounds and supply chains in incorporating 100% renewable energy.

SCOPE

To deal with the increase of integration of hydrogen and other CO2-neutral gases in the energy system and the necessary interactions with electric system and the EU emission trading system, it is necessary to develop assessment studies, increase monitoring and control and design advanced solutions to foster 100% renewable integration in industry and supply chains.

This PPC should address the following:

Assess the impact of the hydrogen market development on the electricity market prices since green hydrogen can be stored in large quantities and used to produce electricity while avoiding spikes that could result from shortage of renewable generation. Similarly, the exploitation of green hydrogen by the industry and by generation of electricity (fuel cells or reconditioned CCGT using hydrogen) will reduce the CO2 emissions, requiring an assessment of the impact on the EU emission trading system (ETS).

Evaluate the viability of using green hydrogen for seasonal storage and security of supply. Large scale development of the generation of electricity based on renewable energy sources (RES) will lead to some surplus of generation regarding the demand, leading to considerable curtailment of RES. Instead of curtailing this renewable electricity, it can be stored via the generation of green hydrogen that would be stored, for instance in salt caverns, to be used as a fuel by reconditioned CCGT or fuel cells that would operate as dispatchable units helping to cover the demand along the year and in this way assuring security of supply levels. The surplus of RES generation may take place in some periods of the year where there is abundance of RES primary energy resources, while in some other the demand is large, and it may happen some scarcity of RES generation. This requires storing renewable energy that is generated in excess during certain times of the year (e.g., during the spring and summer months) and using it to meet demand during other times of the year (e.g., during winter).

The incorporation of CO2 neutral gases (green hydrogen and biogases) in Natural Gas distribution grids will reduce CO2 emissions when consumers use this blended gas, however it is necessary to control the calorific value of the blended gas in order not to compromise the quality of supply to final consumers. The injection of green hydrogen and biogases in the natural gas grid is like the distributed generation in the electrical network, requiring in this case the monitoring and control of calorific values and pressures of injection of renewable gases. Advanced control systems are then required to control the quality of supply and the injection of green hydrogen or other biogases in the natural gas grid. This requires also the adjustment of the billing system, since the continuous changes on the calorific value require time step updates of the effective energy delivered to the consumers. This involves the development of management tools, including state estimation (pressures, gas flows, injections) and control of pressures of renewable gases injections, for these grids when operated with blended gases. Pilots to test the performance of these management tools are needed.

Jointly designing and optimising industrial symbiosis systems can increase the use of renewable energy sources and reduce greenhouse gas emissions. This involves decarbonisation of energy-intensive consumers via joint optimisation enabled by data sharing. This means new distributed optimisation techniques (at different levels of spatial and temporal granularity) capable of providing a valorisation of data (in a Common Data Space) and a coordinated effort across different value chains for an intensive use of the renewable resources. It involves the joint optimisation of their networks infrastructure since the goal is also to optimise their energy conversion processes in a joint manner across the supply/value chain. This can be applied to industrial compounds (producing H2, NH3, fertilisers), or new supply chains..

The PPC is expected to address

- Assessment and monitoring of the impact of large-scale hydrogen production deployment and transportation infrastructure on the electricity markets behaviour and on EU emissions trading system
- Research and demonstration involving pilots capable to demonstrate the success and feasibility of the usage of H2 for large seasonal storage and security of supply.
- Research and demonstration involving the development and test of advanced management and control systems to manage natural gas grids with incorporation of hydrogen and biogases.
- Optimisation of the joint design and operation of industrial symbiosis systems that include the generation of hydrogen considering energy vectors together with different by-products, towards 100% renewable energy systems, in the context of ports, industrial compounds and supply chains.

PPC 1.5: Regulatory framework for cross sector integration

Type of Action: RIA	TRL
Start/End Year: 2024-2029	Indicative Budget: 25 M€

EXPECTED OUTCOME

- Regulatory framework designs and corresponding market design that would provide business cases for cross-sector coupling in low carbon energy future, considering local, regional and international areas.
- Novel regulatory framework and corresponding market designs to cultivate viable business cases for cross-sector coupling, contributing to a low-carbon energy future.
- Regulatory framework designs taking into account the intricacies of integrating diverse energy sectors—electricity, gas, hydrogen, heating, and cooling—while considering local, regional, and international contexts.
- Suitable regulatory framework and cost-effective cross-sector energy markets, crucial for incentivising energy companies to deliver a low/zero carbon future at minimal costs.

SCOPE

It is demonstrated that appropriate integration of energy sectors design and operation will have a major impact on cost-effective transition to low/zero carbon energy future. In this context, the focus of this PPC will be on the development of new regulatory frameworks that would provide business cases for cross-sector coupling in low carbon energy future. One of the key challenges is associated with the need to shift from the incremental to strategic planning paradigm of future energy infrastructure, considering the cross-energy sector integration. Development of appropriate regulatory framework and cost-effective cross-sector energy markets will be critical for providing appropriate incentives for energy companies to deliver low/zero carbon future at lowest costs.

The PPC is expected to address

- Develop novel regulatory strategies for enhancing the interaction between electricity, gas, hydrogen, heating and transport sectors, considering decarbonisation of domestic, commercial and industrial sectors;
- Develop novel regulatory framework that would enable the shift from incremental to strategic energy system planning, considering the interaction between different energy sectors
- Develop new design standards for cross-energy sector infrastructure, including resilience of energy supply
- Develop new collaborative business models for retailers and aggregators, ESCOs and energy communities across different energy sectors
- Develop new market rules and coordination mechanisms for provision of ancillary services by aggregated energy storage and virtual power plants involving cross-sector coupling.

PPC 2.5: Develop a Digital Twin of the European Electricity Grid

Type of Action: IA	TRL
Start/End Year: 2024-2029	Indicative Budget: 35 M€

EXPECTED OUTCOME

- Federated digital twin that will build on initial pilot innovation projects already started or being prepared for in 2023 and be achieved through coordinated investments in five areas: (i) observability and controllability; (ii) efficient infrastructure and network planning; (iii) operations and simulations for a more resilient grid and improved security of supply; (iv) active system management and forecasting to support flexibility and demand response; and (v) data exchange between TSOs and DSOs.
- Fully considered existing mechanisms of coordination among system operators: TSO-TSO, through regional coordination centres, and TSO-DSOs.
- Explicitly considered interoperability and cooperation with legacy systems, both EMSs and existing planning and simulation tools.
- Specified appropriate technical characteristics and timeframes to data, grid models and services exchange. The defined sharing mechanisms must not jeopardise system security and privacy.
- Enabled coupling of market and network constraints, capturing their impact on market prices, reducing congestions and redispatching costs, improving the current Flow-Based method to account for TSOs' remedial actions on PSTs, HVDC or topological actions, while also enhancing TSO/DSOs coordination when local markets are addressed.
- Increased observability and resilience by means of AI exploiting the capabilities of the pan-European digital Twin (topology detection and identification, diagnosis of technical and non-technical losses, CAPEX and OPEX optimisation…) . Real-time data based congestion and edge processing should facilitate predictive maintenance on all elements of the grid.

SCOPE

In today's fast-paced world, the energy sector is constantly evolving and facing challenges that require innovative solutions to keep up with the demands of a carbon neutral society. The complexity of the energy system has increased significantly in recent years with the Energy Transition accelerating, the adoption of more distributed green energy sources and the democratisation of the system through the active participation of local energy communities. This has been further complicated by the global challenges in the last years (pandemics and Ukraine conflict) that have abnormally affected energy prices, security of the supply and even end-user demand habits. In this context, a digital twin of the electricity grid has emerged as a key digital solution to support network operators and market players in making well-informed decisions.

The digital twin technology is based on a virtual replica of the physical grid that mirrors its behaviour in real-time. This allows energy stakeholders to analyse and optimise the performance of the grid, simulate different scenarios and test various solutions in a safe and controlled environment. With the help of digital twins, system operators can quickly identify potential issues and take pre-emptive measures before they escalate into major problems. This reduces downtime and improves the overall efficiency and reliability of the grid.

Moreover, the digital twin technology is a key enabler of innovation in the energy sector. It allows for faster and more efficient testing and deployment of new solutions, reducing the time to market and accelerating the innovation cycle. This is particularly important in the context of the REPowerEU objectives, which aim to integrate higher shares of renewable energies into the energy system. Digital transformation is thus essential to achieve these objectives and ensure the energy system is more efficient, resilient, and sustainable.

The pan-European federated digital twin of the European electricity grid will be a crucial tool for the energy sector in dealing with the rising complexity of the system. Its ability to support decision-making, optimise performance, and accelerate innovation makes it a key enabler of the digital transformation of the European energy system.

<u>The PPC is expected to address</u>

- Propose an open and standardised framework for the interconnection of different vendors. Not only the physical systems connected to the European Digital Twin should be based on open standards, but also the software already used by the system operators should be ready for the interaction on the basis of "no vendor lock-in" solutions.
- Define the business models and market rules supporting the adoption of the pan-European Digital Twin as critical element of the European Electricity Grid.
- Define a pan-European Digital Twin Continuum where different elements on the electricity supply chain could be managed with different level of granularity (HV, MV, LV). Existing Digital Twins of different elements should be able to become part of the continuum offering their dedicated functionalities to the pan-European federated Digital Twin.
- Incorporate into the Digital Twin Continuum the specific needs of energy-intensive industries or large EV fleets, as large demand-side participants, and the needs of local energy communities, as representative of large distributed active users.
- Demonstrate the adaptability of the federated digital twin to different scenarios, from pan-European planning to local coordination between DSOs and end-users -e.g. flexibility management.

PPC 2.6: Viable business cases through market mechanisms and incentives	
Type of Action: RIA	TRL
Start/End Year: 2024-2029	Indicative Budget: 25 M€

EXPECTED OUTCOME

- Increase renewable energy integration through the coordinated effort of aggregating DER and managing electric mobility;
- Improvement on grid stability as a result of a coordinated provision of balancing services;
- Encouragement of the adoption of electric mobility;
- Provision of additional revenue streams for DER entities as a result of their participation in energy and reserve markets, as well as for electrolyser plants from their participation in reserve markets;
- Increase grid efficiency as a result of aggregated DER management that will reduce the need for costly transmission and distribution infrastructures;
- Empowering of end-customers in order to achieve their active participation in the local cluster for generation of renewable electricity and local trading of energy giving them greater control over their energy consumption and bills;
- Reduction of greenhouse gas emissions and mitigation of climate change;
- Increase of resilience of electrical grids and decrease vulnerability to power outages within the local cluster.
- Supporting decarbonisation efforts by incentivising consumers to shift their energy consumption to periods of high renewable energy production.

SCOPE

New business cases resulting from large scale DER aggregation, from large fleets of electrolysers, from increased presence of electric vehicles **and stationary energy storage installation**, from increasing on self-consumption and energy communities require the exploitation of market mechanisms and the identification of specific incentives.

<u>The PPC is expected to address</u>

Development of a comprehensive framework for aggregating large number of small-scale Distributed Energy Resources (DER) for optimal participation in energy and reserves markets to provide reliable and cost-effective energy services. These DER can be aggregated in one or more virtual power plants that can participate in wholesale electricity markets, capacity markets, and ancillary services market and should be able to deal with local distribution grid constraints (ranging from LV to HV). This will require the adoption of advanced forecasting and optimisation tools that can predict the output of the virtual power plants and optimise their performance in real-time based on market conditions and system constraints. An evaluation of market participation strategies that can maximise the value of the virtual power plant in energy and reserves markets should be developed.

Evaluate the technical feasibility and the economic benefits for the electrical grid of having large number of electrolysers participating in balancing services (frequency containment reserve, automatic and manual frequency restoration reserves. To minimise opportunity costs resulting from the operation of the electrolysers below their normal operating point, electrolysers operation should be studied when combined with the operation of renewable power plants, such as wind parks or solar PV plants that may provide the "green" electricity, under a VPP concept, in order to provide downward and upward reserves. Revenue streams from the provision of balancing services should be evaluated by considering the remuneration of the corresponding ancillary services markets in the control areas where they can be operated.

To boost energy flexibility in the electric power systems, it is necessary to promote flexibility-centric cross-sector products, in particular for sectors with high impact in the decarbonisation pathways such as electric mobility, digitalization (i.e., data centres, high performance computing) and water and sewage systems. By designing cross-sector products with green energy at the centre, it is possible to promote a better use of electrical energy (from the system and citizen point of view) and maximise flexibility from small-scale resources by combining energy and non-energy products and services.

The identification of new business models and local markets for collective self-consumption and energy communities is needed, as more individuals and energy communities seek to take control of their energy use and reduce their carbon footprint. The creation of local markets can facilitate decentralized electricity trading and make it easier for end-customers to participate in the energy system.

Circular economy strategies could be applied to promote collaboration among different stakeholders to create, capture, deliver, and share value within the energy systems. Shared value is the cornerstone of collaborative business models. Shared value can not only benefit companies operating in the energy sector by increasing their competitive advantage, but also contribute to the well-being of the communities in which they operate. Shared value can be generated by rethinking products, services and markets; envisioning innovative approaches to the design, production, and distribution of energy-related goods and services that address societal concerns; redefining productivity to minimise waste, energy consumption, and resource inefficiencies and strengthening local clusters fostering collaboration and cooperation among interconnected businesses, suppliers, customers, and other relevant infrastructure and assets within a defined region/district.

The integration of blockchain technology **or any other distributed ledger technology** could play a significant role in the development of local markets for collective self-consumption and renewable energy communities. By utilising **distributed ledger technology**, participants can securely track energy transactions and ensure that all parties are fairly compensated for their contributions. When considering the increase of renewable energy communities, Distribution System Operators (DSO) need also to update their forecasting systems based on these new demand and generation behaviours and design the necessary strategies for better planning and operating their distribution grids. In this context, the traditional line reinforcement strategy can be replaced by a strategy where flexibility provided by the energy community is integrated into the network planning and operation processes. The energy communities can contribute to this better management of the grid by providing ancillary services, either by providing flexibility to resolve congestion or voltage problems, or by providing data to improve DSO estimation algorithms. The monetisation of these services should be addressed to identify the additional revenue values renewable energy communities can get from this participation when trading these services on flexibility markets.

<u>Specific objectives</u>

- The potential impact and economic benefits of large-scale aggregation of small-scale DER for optimal participation in energy and reserves markets through pilot systems;
- The technical and economic benefits from having a large fleet of electrolysers participating in ancillary services provision under a VPP concept where the electrolysers are combined with renewable generation plants. The implementation of a small-scale pilot is envisaged;
- The identification of the potential benefits for stakeholders and electrical grid of cross-sector products focused on energy flexibility to increase renewable energy use, e.g., dynamic discounts for electrical mobility charging. Demonstration projects should be implemented for this purpose.
- The economic and technical impact of collective self-consumption and renewable energy communities when participating in ancillary services markets. Demonstration projects in distribution grids should be implemented for this purpose.

PPC 2.7: Governance for TSO, DSO and System Users (IP 2025+)

Type of Action: RIA	TRL
Start/End Year: 2024-2029	Indicative Budget: 35 M€

EXPECTED OUTCOME

This PPC aims to foster an environment of effective collaboration and coordination among key energy system players. The dynamics of the energy sector are rapidly evolving, with diverse stakeholders, emerging technologies, and complex regulatory demands.

- Enhanced regulatory and administrative framework for an effective and efficient Energy System Governance.
- Developed and demonstrated, enhanced and robust standards for cooperation and coordination among energy system players. Leveraged use of standards for data exchange of data. Defined appropriate data models that can represent properly all the TSO-DSO-System User interactions.
- Enhanced regulatory and administrative framework to achieve efficient Governance of the TSO/DSO collaboration platforms.
- Established robust standards that enhance cooperation and streamline data exchange among TSOs, DSOs, and System Users.
- Defined comprehensive data models that accurately represent all stakeholder interactions,
- Promoted transparency and efficiency within the energy system.

SCOPE

The energy market is currently undergoing significant changes due to the growing presence of distributed energy resources, which are primarily connected at the distribution grid. This increase in distributed energy resources creates a greater demand for flexibility services from system operators, including TSOs and DSOs.

Flexibility becomes crucial when there are substantial deviations in RES production and demand. In such scenarios, flexibility can be employed to regulate and restore grid frequency and voltage, balance individual portfolios, and manage congestion. Thus, the rise of distributed energy resources connected at the distribution grid offers system operators an additional opportunity to utilise these resources for services like frequency control, voltage control, and congestion management at both the distribution and transmission grids. However, a lack of coordination among TSOs, DSOs, and System Users may result in inefficient operation, reducing the collaborative effects between TSOs and DSOs.

The PPC is expected to address

- Develop an efficient energy management platform for TSOs that incorporates interactions with local markets. These local markets can provide support for various services, such as enhancing resilience, managing network constraints and support voltage and frequency regulation in the transmission grid through interactions with TSOs.
- Develop an efficient energy management platform for DSOs that encourages active participation of end consumers/prosumers in local markets. In this case, the local flexibility of end consumers/prosumers can be fully harnessed by DSOs.
- Improve coordination between TSO and DSOs and enhance ancillary service provision through demand flexibility.
- Develop advanced AI-based algorithms for the decision-making process within the TSO-DSO energy management platform.

PPC 3.4: Validation of new market concepts

Type of Action: RIA	TRL
Start/End Year: 2024-2029	Indicative Budget:25 M€

EXPECTED OUTCOME

- Developed and demonstrated advanced technologies and control concepts / platform tools
- Supported multi-energy systems market based on appropriate data exchange between different energy sectors in local, national and international regions.
- Supported decentralised peer-to-peer trading (enabling end consumers to trade energy and ancillary services in real time) while supporting market driven system control (e.g. congestion management) and assess the impact on end consumers services quality.
- Managed uncertainties in the provision of alternative balancing / ancillary services by different technologies (establishing a level-playing field for the provision of services across different service delivery concepts).

SCOPE

The energy transition from fossil fuel to renewable energy requires increased flexibility to balance the less controllable and predictable outputs of renewable energy sources. Multi-energy systems, which involve the integration of electricity, gas, heat, cooling, etc., present a significant opportunity to achieve system flexibility by utilising multiple energy carriers. Peer-to-peer energy trading allows end consumers/prosumers to trade energy locally, independently of the upstream utility company. Peer-to-peer energy trading offers benefits such as reducing energy costs, balancing local demand and supply, and avoiding or deferring network reinforcement. Additionally, at the national transmission level, the flexibility of end consumers/prosumers can be leveraged to provide balancing services, which become increasingly valuable as the volume of renewable energy resources in the market grows. Key objectives are

- Develop an appropriate market mechanism that would incentivise end consumers/prosumers with multi-energy systems to engage in cooperative local energy trading and flexibility service provision. The market should optimise both local energy trading and flexibility services.
- Validate the interactions and efficiency across different market levels, including wholesale, retail, and local markets.
- Investigate the impact of local flexibility (including flexible demand, energy storage systems, and local trading) on market efficiency.
- Validate the scalability of the designed market in order allows a large population of consumer/prosumer to participate in the multi-energy systems market.
- Demonstrate robust trading strategies for end consumers/prosumers participating in the multi-energy systems market, taking into account various uncertainties (e.g., PV generation, load patterns, usage behaviours) and dynamics (e.g., real-time adjustments of market participants' strategies).
- Investigate / demonstrate data-driven trading strategies for end consumers/prosumers participating in the multi-energy systems market. The strategy should be model-free and privacy-preserving, and can optimise the trading strategy without prior knowledge about the simulated multi-energy systems and market operation principles.

PPC 4.5: Well-functioning markets for a RES based energy system

Type of Action: RIA	TRL
Start/End Year: 2024-2029	Indicative Budget: 25 M€

EXPECTED OUTCOME

- Ensured appropriate mechanisms for market participation from RES at multiple levels, from local to global scale, and from heterogeneous energy sectors, ensuring viable business cases and backed by supporting regulations;
- Ensured stability of the energy system by reduced risk for vulnerable consumers under a market design with massive penetration of renewables;
- Ensured market mechanisms for transparency and non-discriminatory behavior

SCOPE

This work will inform the development of well coordinated markets for meeting security of supply requirements, energy delivery and ancillary services, to support cost effective integration of RES. This should specifically address core challenges related to the development of cost-effective market design, and therefore the key objectives are

- Develop radically new market mechanism for provision of stability services at minimum costs, which will be critical for RES dominated grids, given massive reduction in system inertia.
- Develop a market mechanism where controlled RES will play a critical role in ameliorating their own contributions to instabilities and enhancing the overall stability of the system.
- Include pricing of the provision of system inertia in the new market, given that wind turbines and storage could provide synthetic inertia and reduce system integration costs.
- Develop a new approach for allocation of system balancing costs. These costs are currently socialised, not providing any signals for future technology developments.

PPC 4.6: Policies and governance for a RES based energy system

Type of Action: RIA	TRL
Start/End Year: 2024-2029	Indicative Budget: 25 M€

EXPECTED OUTCOME

- Increased investments in new firm generation capacity involving H2 plants;
- Improved reliability of the generation system and security of supply;
- Cost savings for electricity consumers;
- Increased use of renewable energy sources;
- Reduced CO2 emissions;
- Avoided double energy access tariffication (costs of general economic interest) in Power2Power solutions and assuring cost savings for consumers;
- Improved market competition among energy providers;

SCOPE

New policies and regulations that promote the deployment of renewable power sources need to involve product standardisation, remuneration solutions that promote the development of firm capacity with reduced or zero CO2 emissions to keep security of supply, adequate use of energy access tariffs and incentives to increase flexibility from changes in grid topology.

<u>The PPC is expected to address</u>

Development of advanced flexibility markets, and new product standardisation for ancillary services provision, allowing for the efficient management of electricity supply and demand. The design of flexibility markets should be addressed by defining rules governing their operation and the products they offer ensuring that these solutions promote fair competition, minimise market power, and enable the efficient and reliable operation of the power system. Standardisation of ancillary services products offered in flexibility markets can help ensure that they are easily understood by market participants and can be efficiently traded. This standardisation should also promote liquidity and reduce transaction costs in the market. The adoption of these standards can be tested in small pilots within some of the control areas of the European electric grid.

Development of transitional regulation solutions to assure firm capacity when using green hydrogen to fuel power plants. This involves the evaluation of the adequacy of capacity remuneration solutions to leverage the development of hydrogen plants (using fuel cells or refurbished gas turbines) that exploit stored hydrogen generated from the surplus of renewable electricity. The adoption of capacity markets and the corresponding remuneration for these plants needs to be compared with alternative solutions like rate of return-based remuneration schemes and feed in tariffs. This economic feasibility analysis needs to be addressed for the expected time duration of these investments using alternative remuneration solutions that need all to be compared with the Value of Loss of Load (VoLL) to assess projects feasibility, according to the European Directives.

Identification of fair solutions for energy transmission tariffs and other energy policy tariffs often used to avoid double tariffication in Power2Power (P2P) projects. In P2P projects, renewable electricity is feeding electrolysers that produce hydrogen used afterwards to fuel dispatchable plants that guarantee the coverage of demand. Electrolysers may also be involved in sector coupling approaches producing hydrogen to be exploited as another energy vector or to blend with natural gas in gas distribution gids. Analysis of the adequacy on the exemption or adjustment of part of access tariffs by electrolysers when operated for such purposes and for these cases needs to be addressed. Final end consumers should not pay twice the energy policy tariffs when using the electricity under a P2P approach or when hydrogen is delivered through gas distribution infrastructures. Adequate recommendations on energy policies that address the problem of access tariffs for this framework in different state members of EU are required.

Identification of regulatory incentives and targeted policies to foster the adoption of grid topology flexibility approaches for TSO and DSO, which are completely CO_2 free (in contrast to actions such as RES curtailment, demand response, etc.). TSO and DSO operate their grids by using usually fixed topologies, which may lead to renewable generation curtailment, exploitation of storage strategies and or the adoption of demand response. Changes on grid topology at the substation level, or in the grid, through the optimum location and exploitation of soft open points, need to be studied and exploited. This requires investment on new hardware to be installed on the grids, development and investment in new simulation tools to be used at the DMS and EMS level and transposition of these lessons to the planning of the grid under a new dynamic and flexible operation and planning paradigm that is adaptable to the variability of load and renewable generation along the day and the year. Pilots using areas of transmission and distribution grids characterised by large integration of renewable generation (where renewable curtailment is taking place) should be used to test the benefits of grid flexibility solutions.

Specific Objectives

- Advanced flexibility markets where new products and new standards are used for ancillary systems provision.
- Transitional regulation solutions to assure firm dispatchable capacity based on renewable energy through the exploitation of Power 2 Power concepts associated with green hydrogen use.
- New policies to define adjustments over access tariffs for Power2Power and sector coupling solutions.
- Regulatory incentives and policies to promote grid topology flexibility which is CO_2 free (in contrast to actions such as RES curtailment, demand response), involving demos and pilots.

PPC 5.5: Data Spaces

Type of Action: RIA	TRL
Start/End Year: 2024-2029	Indicative Budget: 35 M€

EXPECTED OUTCOME

- Successfully deployed federated energy data spaces across diverse infrastructures/ energy system actors and integrating several related sectors of the economy and society (and respective data spaces) through advanced and flexible (cross-data spaces) data interoperability and sharing mechanisms.
- Increased data availability and advanced mechanisms for streamlined, interoperable and highly reliable data collection from IoT and distributed DERs, at scale.
- Integrated data value chains respecting data providers' interests through advanced federated technologies addressing the whole life-cycle of energy data in a secure and sovereign manner.
- Improved data discovery, exploration and access (in line with the FAIR principles) across federated deployments of energy (and relevant sectorial) data spaces at local, national and/ or EU level.
- Promoted data markets and data economy through the fair valuation, evident pricing and trading of energy (and related sectors') data.
- Fostered innovation in data and intelligence-driven energy services and automated market functions, to promote the establishment of integrated service value chains by stepping on increased energy data availability, integration of data from other sectors' data spaces and federated intelligence, while considering constraints introduced by federated energy data spaces deployments.

SCOPE

To meet the REPowerEU ambitious decarbonisation and sustainability goals, the twin green and digital transition calls for a better-functioning, smart, integrated, and cleaner energy system. The integration and decarbonisation of the energy system shall ensure independence from fossil fuels and security of supply with increased integration of Renewable Energy Sources (RES) in the energy mix and unleash/ utilization of the flexibility potential of energy systems assets, the demand side and coupled sectors for safeguarding the resilient operation of energy grids.

Advanced data governance across federated energy (and other sectors') data spaces, complemented with innovative data sharing mechanisms and trading models are emerging as key enablers to accelerate the pace and scale of the energy system (and value chain) integration, which is expected to progress dramatically over the years to come, and give birth to novel and integrated data value chains and service ecosystems that can effectively achieve in:

(i) Safeguarding energy system resilience by introducing vast amounts of distributed flexibility in new system operation routines and strategies;

(ii) Putting people first and enabling citizens, prosumers and local energy communities to obtain active roles in energy markets and fairly benefit from their participation

(iii) Promoting new opportunities for businesses to provide innovative, secure and trustworthy data-driven and AI-enabled solutions and services.

In this context, proposed actions shall develop, demonstrate and validate at scale, a Federated Energy Data Spaces framework that is characterised by the following features:

- Streamlined, formalised and standards-based methods and mechanisms for integrating data assets from a wide variety of DERs, flexible assets and IoT devices, towards increasing data reach across the edges of the energy system (and beyond) and facilitating the involvement of non-expert data owners (prosumers, communities, EV owners, etc) in data sharing.
- Federated management of distributed data assets across their entire life cycle (from data generation/collection to the final use and disposal/deletion of data especially when required by applicable legislation, for example the General Data Protection Regulation), as the primary means for safeguarding data sovereignty, privacy and confidentiality, complemented by intelligent mechanisms for data security and protection that can effectively ensure data utility.
- Flexible, extendible and simplified data interoperability mechanisms and tools, ensuring seamless integration of energy data (and fast adaptation to new data assets (addressing emerging IoT, energy and grid technologies) with low maintenance effort.
- Building on existing and emerging standards, models and architectures and complement/expand them as necessary in view of interoperability and portability of data, especially between energy and relevant sectorial data spaces.
- Performant and smart discovery and exploration of data across federated energy and other relevant sectors' data spaces.
- Immutable and trustful data sharing mechanisms facilitating federated exchange of data in a secure and transparent manner, under high energy-efficiency terms.
- Novel mechanisms and models for objective valuation of data transactions that can reliably satisfy the needs, expectations and rights of the data providers and owners, together with the business value for data consumers.
- Open and customisable data provisioning and self-serving mechanisms and standards-based interfaces, adhering to data access rights and data sharing agreements.
- Ability to accommodate and interoperate with federated intelligence mechanisms towards generating valuable knowledge and tradeable data derivatives from confidential data, minimizing the need for any actual data transfers.
- Support the creation of an ever-growing innovation ecosystem around the federated energy data spaces framework, by fuelling technology uptake and engagement of IT providers and SMEs/ startups in data sharing for enhancing the data-driven character of existing digital solutions (e.g. Digital Twins) and/ or developing new data and intelligence-powered energy services.
- Further support the proliferation of transparent and fair involvement of prosumers in energy markets and activities.
- Promote the creation of an inclusive, integrated service and market ecosystem across the energy sector, for the collective end-to-end optimisation and resilient operation of the energy system under high degree of distributed flexibility.

5.6: Building skills needed for developers and users of the energy system to accelerate its transition through its digitalization

Type of Action: CSA	TRL
Start/End Year: 2024-2029	Indicative Budget: 25 M€

EXPECTED OUTCOME

- Digital skills platform for supporting and accelerating Energy transition through its digitalization, offering educational (including tertiary (university) and secondary level education (Both high and vocational schools) and training programs, including upskilling and reskilling, disseminating best practices and ensuring that skills demand from industry and users is matched with the offer from education institutes and training providers.

- Developed digital skills platform designed to foster and expedite the Energy transition via digitalization. This platform should offer a set of training programs tailored to meet diverse learning needs, including upskilling and reskilling opportunities. The goal is to disseminate industry best practices and bridge the gap between the skill demands of the industry, users, and the offerings of training providers. This strategic initiative is designed to cultivate a well-equipped workforce, ready to navigate the complexities of the digitalised Energy sector.

SCOPE

The challenge of detecting skills gaps between demand and offer is great and has to be continuous. The activities to reduce and fill up the gaps is a major issue, as there many involved stakeholders and has to be also continuous. The great variety among the countries within Europe makes them more complex.

Methodologies to detect gaps have been developed and the dissemination of best practices is a well proven way to reduce gaps. Moreover, analysis of gaps has to be done taking into account all levels of workers and all levels of education and training, from academia to vocational levels.

Also, a major challenge is to address these activities to users of energy, not limiting the effort to the industrial value chain.

Furthermore**,** this PPC should cover all the following aspects:

Identify Needs: Conduct a comprehensive needs assessment to identify the skills required for the energy transition and the current gaps in training provision. This should involve consulting with industry, users, and existing training providers.

Design and develop the Platform: Design and develop the platform to be user-friendly, accessible, and versatile. It should support a variety of learning formats (e.g., video, text, interactive content) and be adaptable to various devices (computers, tablets, smartphones).

Develop Content: Create high-quality, relevant training content that addresses the identified skills gaps. This may include theoretical knowledge, practical skills, and industry best practices. Consider different levels of expertise and learning preferences when developing content.

Incorporate Upskilling and Reskilling Programs: Design specific programs for upskilling and reskilling, helping professionals adapt to the changing energy sector. These could be short courses for developing specific skills or longer programs for gaining broader knowledge.

Develop a Skills Matching Tool: Develop a tool that matches the skills demand from industry and users with the training offer from providers. This could involve a search function, recommendations, or a matching algorithm.

Promote the platform: Promote the platform to the target audience. This could involve social media marketing, email campaigns, partnerships with industry bodies, and more.

PPC 5.7: Service management and operations

Type of Action: IA	TRL
Start/End Year 2024-2029	Indicative Budget: 25 M€

EXPECTED OUTCOME

- Designs of adequate Service Management for digitalised energy system and processes based on new business models, new revenue streams and value producing opportunities: Setup appropriate service management processes, systems and organisations that meet demand for superior customer service and deals with strong competition.
- Effective Service Management framework, digitizing the energy system and streamlining processes under the aegis of innovative business models, untapped revenue streams, and value-creating opportunities.
- Established robust service management procedures, systems, and organisations that cater to the demand for superior customer service and effectively navigate stiff competition.

SCOPE

To achieve the service management and operation procedures the following steps are required:

Service Management Framework: Construct a comprehensive framework for service management that aligns with the power system value chain, and the needs of all actors involved, including consumers. This plan should encompass all aspects of service delivery such as procedures, roles, technology, and performance metrics. The design should take into account cyber security aspects.

Stakeholder Engagement: Engage with all relevant stakeholders in the power system value chain. This includes consumers, suppliers, energy producers, grid operators, and regulatory bodies. Their insights will be critical in shaping the design and implementation of your service management processes.

Business Model Innovation: Innovate new business models that leverage the opportunities of digital transformation within the power system value chain. These models should focus on creating new revenue streams and value-creation opportunities for all actors involved, including consumers.

Service Management Platform: Implement the service management design, focusing on the needs of the power system value chain. This involves setting up the required systems and organisations, training staff, and integrating the new processes into your operations.

Project Demonstration: This demonstration would involve a real-world application of the designed service management framework in X locations. The demonstration should include TSOs (both gas and electricity), DSOs (both gas and electricity), retailers, producers, aggregators and other actors. The demonstrators should consider, local and the coupled market systems, EMS, DMS, AMI, DR, etc.

PPC 5.8: Sharing IT infrastructure investments

Type of Action: CSA	TRL
Start/End Year: 2024-2029	Indicative Budget: 25 M€

EXPECTED OUTCOME

- Leveraged IT infrastructure effectively, engaging multiple stakeholders within the energy sector.
- Harnessed power of digitalization to innovate business models and streamline processes within the energy system.
- Fostered creation of novel business models, untapped revenue streams, and value-generating opportunities.
- Incentivised development of sophisticated communication infrastructures by identifying relevant systems and proposing a balanced funding scheme for all participating entities.

SCOPE

The following aspects should be assessed in this PPC:

Stakeholder Identification and Engagement: Identify the key actors within the energy sector who could benefit from and contribute to improved IT infrastructure and digitalization. This could include utility companies, energy producers, grid operators, regulators, and customers. Engage with these stakeholders to understand their needs, constraints, and capabilities.

Infrastructure Assessment: Conduct a comprehensive assessment of the existing IT infrastructure within the energy domain. Identify areas where improvements or upgrades are needed, and where new common infrastructure could be beneficial.

Digitalization Strategy: Assessment of the Digitalisation for Energy Action Plan focusing on areas where digital technology can bring the most significant improvements. This could involve automation, data analytics, AI, or other cutting-edge technologies.

Business Model Innovation: With digitalization as a foundation, explore new business models that could be developed. This might include services based on energy data, value-added services for customers, or new ways of managing and distributing energy.

Revenue Stream and Value Creation: Identify potential new revenue streams and value creation opportunities arising from these business models. This could involve market research, financial modelling, and stakeholder engagement.

Incentive Scheme Development: Create incentives for stakeholders to develop and adopt advanced communication infrastructures. This could involve a mix of regulatory incentives, financial rewards, and reputational benefits.

Funding Scheme Proposal: Develop a proposal for a fair and balanced funding scheme that supports the development and deployment of this advanced infrastructure. This should take into account the benefits and costs for all involved parties.

PPC 7.5: Grid operator of the future

Type of Action: RIA	TRL
Start/End Year: 2024-2029	Indicative Budget: 25 M€

EXPECTED OUTCOME

- Established skills requirements and training plans for the operator of the grid as its supervision and control systems evolve to the future in both areas. Massive integration of DER´s and adoption of new digital technologies.
- Established and developed requisite skills and training programs for operators navigating the rapidly evolving landscape of electricity networks. As the energy infrastructure undergoes seismic shifts, with the large-scale integration of DER and the adoption of novel digital technologies, the operators need to be equipped with the right skills to manage these changes efficiently. This PPC will focus on identifying these vital skills and formulating comprehensive training plans to ensure our operators are at the cutting edge of industry advancements. A crucial aspect of this project will be the training of the operators on cybersecurity measures that safeguard the digital systems.

SCOPE

This is a continuing and dynamic PPC as the control room operator will use departing legacy systems in a continuous evolution towards ving way adopting new equipment and applications to be developed under other PPCs within this HLUC (Enhance System Supervision and Control including Cybersecurity) specifically: PPC 7.1 (Next generation of TSO Control Room), PPC 7.2 (Next generation of DMS Distribution Management Systems), PPC 7.3 (Next generation of measurements and GLS for distribution grids) and PPC 7.4 (Wide area monitoring, control and protections).

Special attention has also to be paid to the following PPCs:

PPC 7.7 Human machine interfaces, where summarised information has to be presented to the operator to allow appropriate and timely decisions.

PPC 7.8 Cybersecurity for Energy Networks, where, as it has been well experienced, Control Rooms are the targets of many attacks and have to be recognised as critical systems.

Electrical system works in real time. In this environment Control Rooms operators do not have long times to react and they have to be supported by many applications which will tend to “operate automatically”. Proper balance of human final decision vs. machine (applications) actions must be established.

Another critical aspect is the careful attention to security during instructions for human beings (i.e. operating personnel, like field crews maintaining or operating live electrical equipment, even in the dangerousunder high voltage conditions space) and critical environments (i.e. avoiding causes for fires, etc.)

In this context, the follow up and analysis of control rooms of other industries dealing with real time and safety (i.e. aviation aero-controllers) will be very much recommended.

Continuous education and training plans especially for grid operators have to be established and certified including initial skills, upskilling and reskilling in a long-life learning process.

Important aspects to consider for this PPC:

Skills Gap Analysis: Carry out a detailed analysis to identify the skills required for managing new technologies and the evolving power system network and the current competencies of the operators. This will help identify any gaps that need to be addressed.

Training Program Development: Develop comprehensive training programs based on the identified skills gap. The programs should cater to various learning styles and be designed to facilitate the understanding and adoption of new technologies and practices. Application of Digital Twins for training under safe and realistic simulated conditions.

E-Learning Platforms: Utilise online platforms that offer flexibility in learning. This would allow for self-paced learning, reduce costs, and make it easier to update content as industry advancements occur.

Cybersecurity Training: Given the increasing reliance on digital technologies, a crucial aspect of this project will be training operators in cybersecurity best practices. This should cover everything from understanding potential threats to implementing effective countermeasures.

Integration of DERs: Train operators on the integration, management, and benefits of DERs) This will require a deep understanding of these resources and how they fit into the overall energy system.

Adaptation to Digital Technologies: As new technologies are adopted, operators will need training on how to use these effectively. This could involve everything from using new software systems to understanding the implications of AI and machine learning for energy management.

Continuous Learning and Improvement: It's important to foster a culture of continuous learning and improvement. This could involve regular training updates, performance reviews, and the opportunity for operators to provide feedback on their training.

Partnerships and Collaboration: Collaborate with educational institutions, industry experts, and technology providers to ensure that the training is up-to-date, relevant, and effective. This could also involve partnerships with other companies for shared learning and best practice exchange.

Evaluation and Impact Assessment: Regularly evaluate the effectiveness of the training programs and their impact on operator performance and the overall functioning of the power system network. This will help ensure that the training is delivering the desired outcomes and inform any necessary adjustments.

PPC 7.6 Grid field workforce of the future

Type of Action: RIA	TRL
Start/End Year: 2024-2029	Indicative Budget: 25 M€

EXPECTED OUTCOME

- Established skills requirements and training plans for the field workers of the grids, capable to actuate with the new network topologies and actors, within the massive integration of DERs and the use of continuously improved tools and applications to support their job.

SCOPE

This is a dynamic PPC as there is a continuous modification of networks due to the integration of DERs (renewable generation, batteries, EV chargers, etc.) with the concourse of many different actors as well as the continuous adoption of advanced technologies, electronic equipment and devices, different than the existing traditional electric equipment, which require new testing and repairing technologies with a need for a full skill in software upgrading.

Also, the adoption of new supportive devices being capable of acceding remotely to all types of needed information.

Special attention has to be paid to human safety as well as environmental protection.

Cybersecurity is also an important aspect to include as more control is distributed arriving to the lower levels of voltage networks.

Use of virtual learning environments, like virtual secondary substations classes, will be quite instrumental for establishing adequate plans for initial skills, upskilling and reskilling in a long-life learning process.

Also, as there is a clear trend for outsourcing the field work, very special attention has to be paid for following training plans and certifying skills to the subcontractors or outsourced companies in all areas.

Finally, telecommunications technologies and services must be a fundamental part of training as not only the smart grid devices but also field workforce will rely very much on their services.

PPC 7.7: Human machine interface	
Type of Action: RIA	TRL
Start/End Year: 2024-2029	Indicative Budget: 25 M€

EXPECTED OUTCOME

- Designs for effective ways to present data to the operator and the way the HMI drives the possibility of interaction of the operator, as the automation level grows and more data becomes available. There will be a clear trend to distribute control allowing automatic actions in the network that must be well supervised and controlled in a coordinated way by the control room operator(s).
- Enhanced data presentation and how the HMI drives the possibility of interaction of the operator. As the automation level grows, more data also become available. The role of the operator in the control room is changing but this means that one needs to rethink also how data is presented and how the HMI drives the possibility of interaction of the operator (From the ETIP SNET IP 2022-2025)
- Designs of innovative strategies to effectively present data to operators of the future electricity system, emphasizing the enhancement of the Human-Machine Interface (HMI) to foster optimal operator interaction. As automation levels rise and data availability surges, the role of the HMI is becoming increasingly critical. The objective is to create an HMI capable of managing this growing complexity, ensuring the seamless integration of operator control and automated systems.
- Applications for both transmission and distribution power grids, central dispatch centers, management of renewable energy production plants, and microgrids.
- Evolved human-machine interaction to become more analytical and summary-oriented, with a dashboard presenting global performance indicators, operational risks, and reports of automatic self-healing and optimisation mechanisms, as opposed to the traditional SCADA operation based on telemetry, alarms, and conventional automation.
- HMI designs applicable in local stations at substations, production power plants, fully monitored secondary substations, micro-grids, and energy communities. Here, the interaction will primarily involve summary monitoring of automatic decisions, gradually transitioning to mobile devices instead of traditional screen-based workstations.
- Gradually integrated AI into operation workstations to aid in grid and energy asset management. This integration will impact human-machine interaction, introducing virtual operation assistants equipped with natural language models, operation convenience suggestions, and more. The aim is to create an efficient, versatile, and user-friendly interface that can adapt to the evolving demands of the energy sector.

SCOPE

To meet the goals, a set of specific tools and solutions should be developed:

Advanced Data Visualisation Tools: Utilise data visualisation software to present complex data in a clear and digestible format. These tools can help operators easily understand global performance indicators, operational risks, and automatic self-healing and optimisation mechanisms.

AI-Powered Dashboard: Develop an AI-powered dashboard that provides real-time analytics, predictive insights, and summary monitoring of automatic decisions. This will provide operators with a comprehensive overview of the system's performance and highlight any areas that require attention.

Mobile Application: Develop a mobile application to allow operators to monitor and control the system remotely. The app should be user-friendly, secure, and able to provide key information in a clear and concise format.

Virtual Assistant: Incorporate a virtual assistant powered by advanced natural language processing. This tool can help operators with tasks, answer queries, and provide operation convenience suggestions.

Automation Software: Implement automation software that can handle routine tasks, freeing up operators to focus on more complex issues. This software should be integrated with the overall system and allow for a high degree of customization to meet specific needs.

Training Programs: Develop comprehensive training programs to help operators understand and effectively use these tools. This should include both technical training on how to use the tools and conceptual training on how to interpret the data and insights they provide.

Predictive Analytics: Leverage AI and machine learning to provide predictive analytics, helping operators anticipate and address potential issues before they become critical problems.

Integration Platform: Develop a platform to ensure that all these solutions can work together seamlessly, creating a unified, efficient, and effective system for managing the power grid.

PPC 7.8: Cybersecurity of Energy Networks

Type of Action: RIA	TRL
Start/End Year: 2024-2029	Indicative Budget: 35 M€

EXPECTED OUTCOME

PPC 7.8 outcomes should be in compliance with the Cybersecurity Network Code PPC 7.8

- Enhanced security measures by design through assessment of vulnerabilities and threats of the Energy sector.
- Fostered standardisation, certification and recommendations on EU energy information exchange.
- Improved protection efficiency of new and existing energy assets against cyberattacks.
- Developed and tested procedures to prevent and react to large scale cyber-attacks.
- Ensured energy data integrity and boost forensic methodology.
- Promoted collaboration with third country parties. Cybersecurity does not stop at the EU borders. It is critical to support neighbouring countries in achieving similar maturity level of cyber resilience and cooperation mechanisms.
- Develop secure block chain based mechanisms

SCOPE

The increasing integration of digital technologies in the energy sector has brought new challenges in terms of cybersecurity. With the growing number of connected devices and the use of cloud computing and data analytics, the energy infrastructure is becoming more vulnerable to cyber-attacks. This makes cybersecurity risk management a critical factor in maintaining the security of supply and ensuring a high level of cybersecurity in the energy domain.

The digitalization of the energy sector has brought many benefits, but it has also increased the risk of cyber threats. Therefore, cybersecurity has become a strategic priority for critical energy infrastructure. The deployment of cybersecurity measures is necessary to protect against potential cyber threats and minimise the risk of disruption or downtime in the energy system.

Cybersecurity and digitalization are closely interlinked and have become essential to provide essential services in the energy domain. Therefore, it is crucial to integrate cybersecurity into the energy system design, development, and operation, and to ensure that it is included as a critical factor in decision-making. This will enhance the resilience of the energy infrastructure, minimise the risk of cyber threats, and ensure the provision of secure and reliable energy services to consumers.

PPCs are expected to:

- Analyse the current and the future Directives on cyber security and consider all forms of energy networks: electricity, gas and hydrogen.
- Identify the specific ICT services, systems or products that might be subjected to coordinated risk assessments with priority, including risks in the renewable energy, e.g. offshore wind and grid supply chain.
- Propose effective processes for crisis management to handle energy cybersecurity incidents involving more than one national stakeholder or stakeholders of cross-border relevance.
- Define training mechanisms for energy cybersecurity exercises to increase resilience and improve the risk preparedness of the energy sector.
- Implement and demonstrate a robust dynamic Cyber-Risk Evaluation methodology in order to detect threats and vulnerability of the targeted IT/OT environments in near real-time conditions and to propose corresponding mitigation actions.
- Establish minimum alerts and threat detection flows by setting up a system for the collection and sharing of essential information in relation to cyber incidents in the energy domain at EU level.
- Increase cyber situational awareness and improve response to cyberattacks by proposing a solid cooperation framework for cybersecurity aspects of cross-border energy flows in order to ensure the reliability of the energy systems and to ensure close collaboration with existing governance structure(s) for cybersecurity.
- Analyse the business models supporting the adoption of a cooperative energy cybersecurity framework at EU level.
- Determine a set of common criteria to perform risk assessments based on defined risk scenarios for the operational reliability of the energy systems with regard to cross-border flows and cascading attacks.

- Demonstrate energy sector' cyber resilience to different attacks by exercising, simulation and real testing.

PPC 8.3 Integrated planning of energy and transport sectors

Type of Action: RIA	TRL
Start/End Year: 2024-2029	Indicative Budget: 20 M€

EXPECTED OUTCOME

The strategic planning of the energy and transport sectors is increasingly moving towards a more integrated approach, including the probabilistic system planning strategies. These strategies factor in the extensive impacts of large-scale deployment of diverse transport sector and energy storage technologies. Concurrently, it is needed to evolve electricity system design codes to ensure that the contribution of EV smart charging and vehicle-to-grid (V2G) services is securely included. This includes considerations for both slow and rapid charging infrastructures, aligning with our environmental responsibilities. Lastly, it's crucial to incorporate efficient recycling strategies for batteries, and measures to preserve health, into our planning to ensure a sustainable and inclusive transition to the future of energy and transportation.

SCOPE

As we march towards a future underpinned by sustainable energy and advanced transportation systems, it's imperative that we strategically integrate these sectors to optimise efficiencies, reduce environmental impact, and ensure resilience. The intrinsic interdependencies between energy production, distribution, and consumption in the transportation sector require a holistic approach to planning and implementation. To support this complex process of integrated planning, there's an emerging need to develop a comprehensive set of tools and methodologies. These tools and methodologies will not only enhance our ability to model, simulate, and assess various scenarios but also aid in ensuring that decisions are data-driven, inclusive, and considerate of multiple dimensions - economic, environmental, and social. This will help pave the way for a harmonious, sustainable, and efficient integration of the energy and transport sectors:

- Integrated Energy-Transport Modelling Tool: While separate tools exist for modeling the energy and transport sectors, an integrated tool could provide more accurate simulations and analysis.
- Dynamic Load Management Systems for EV Charging: Advanced systems that allow utilities to manage EV charging loads in real-time, taking into account grid constraints, renewable generation, and user preferences.
- AI-based Predictive Maintenance Tools: These could anticipate potential faults or inefficiencies in the energy and transport systems, thus reducing downtime and operational costs.
- Enhanced Cybersecurity Tools: Given the increasing digitalization and interconnectivity, there's a need for advanced cybersecurity tools to protect the integrated systems from potential threats.
- Holistic Risk Assessment Methodology: A methodology that considers not only technical risks, but also environmental, social, and economic risks related to the integration of energy and transport sectors.
- Dynamic Scenario Planning: Traditional scenario planning may not be sufficient given the rapid changes in technology and policy. A more dynamic approach, allowing for frequent updates and adjustments, would be beneficial.
- Collaborative Decision-making Process: A methodology that fosters collaboration among all stakeholders, balancing their diverse interests and perspectives in the planning process.
- Integrated Impact Assessment: Rather than separate assessments for the environment, society, and economy, an integrated assessment could provide a more comprehensive view of the impacts.
- Technology Readiness Assessment: A specific assessment of the readiness level of different technologies to be deployed at a large scale. This would include not only technical aspects but also manufacturing capabilities, regulatory considerations, and market acceptance.
- Resilience Assessment: Given the increasing threats of climate change and cybersecurity attacks, an assessment of the resilience of the integrated energy and transport systems would be crucial.

PPC 8.4: Adapting policy and market for seamless cost-effective merging of transport and energy sectors

Type of Action: RIA	TRL

Start/End Year: 2024-2029	Indicative Budget: 20M€

EXPECTED OUTCOME

It is estimated that the percentage of cars and vans fuelled by alternative fuels will reach 50% by 2050, growing tenfolds. This is supported by the recent Alternative Fuels Infractructure regulation that sets concrete targets for Member States to deploy the relevant infrastructures on the TEN-T. For this reason, Alternative fuels vehicles and in particular hydrogen fuelled and electric vehicles will be widespread our roads.

- Developed appropriate market design to enable smart connectivity and use of the multi-energy system through responsive (V2X) charging infrastructure is needed.
- Modified regulatory framework to enhance TSO–DSO interaction in energy grids, starting from the electric grid, in supporting cost effective solutions for the transport sector is quite necessary.
- Required changes in the design of the energy market with reference to the management of Electric Vehicles and to assess appropriate costs/revenues related to the operation of the charging infrastructure (e.g. establishment of electro-mobility market for system services).
- Assessed Costs/revenues so as to consider possible ageing mechanisms caused by the V2X operation.
- Established electro-mobility ancillary services market;
- Responsive electric vehicles (EVs) through the development of new business models and a suitable regulatory framework;
- Digital identities for devices and people across the electro-mobility market;
- Established decision making process about logistics of transports with electromobility (also supported by digital twins models).

SCOPE

This topic's scope relates to both the market perspective (especially new actors and roles, etc.) and the policy perspective considering the technological framework, addressing the development of new approaches based on digital twins and artificial intelligence (AI) employed in providing a perspective to decision makers and market actors and at the same time designing an optimised operation of EVs considering both grid support and end-users needs.

PPCs should involve all relevant stakeholders and are expected to address at least 3 of the following aspects:

- Development of data driven decision making for the energy and power management in the Electro-mobility market, minimizing the battery ageing and discomfort.
- Development and testing in a virtual environment of innovative electro-mobility market models also including V2G and V2V operation.
- Design of safe, accessible and reliable operation of EVs and relevant batteries and compatible with the battery passport concept.
- Design of a tracking system for life cycle cost around the EV, transparently but safely managing digital identities of people and goods.

PPC 9.4: Governance for an effective integration of buildings and smart energy communities

Type of Action: RIA	TRL
Start/End Year: 2024-2029	Indicative Budget: 20M€

EXPECTED OUTCOME

The new Energy Performance in Buildings proposal is set around the definition of Zero Energy Buildings, while new certification mechanisms for buildings integrate the idea of a certification system that will look at emissions along the whole life cycle and that integrates and action plan about their refurbishment in the view of zero emissions by 2050.

- Developed design solutions for setting up and operating active and flexible energy buildings and communities that will offer optimal solutions to the tenants, users and the community as an entity is thus needed.
- Deployed practices and systems that will cover design (possibly considering whole life-cycle), use and disposal of appropriate smart technologies and systems and develop appropriate codes, standards and regulations for coordination mechanisms with system operators and multiple energy stakeholders.
- Identified best practice governance options for buildings and energy communities. New business models for the provision of services to multi-energy systems operators will support the optimisation of the efficiency of the different energy devices

interacting with the electrical grid. In the design of the smart technologies, it is advisable to account for Critical Raw Materials provision or supply risk.

- Hardware/software optimisation process underlying the data management at the different levels of processing (i.e.: building; community; cloud-edge; distributed computation) will contribute to minimise emissions in data management.
- Deployment of smart and Zero Emission Buildings for both private and public use and to the integration of renewable energy sources in the energy system.
- Demonstrated interaction of more buildings and energy communities technical systems efficiently managing different energy flows, considering the operation efficiency of these systems interacting with the electrical grid, and providing flexibility services.
- Interaction models considering public and private entities.
- Demonstrated technologies for data aggregation and synthesis to minimise and optimise data flows while preserving security and privacy.
- Accounting procedure for Critical Raw materials and supply chain risks used in the deployment of the smart technologies.

SCOPE

PPCs should involve all relevant stakeholders and are expected to address all of the following aspects:

- Develop integrated solutions to aggregate flexibility from private and public electrical energy consumers with interoperable platforms and secure data management.
- Cooperate with at least one TSO or one DSO and set up a cooperative platform for them to exchange data between them and with end-users and build on fully integrated demand of services (from TSO or DSO).
- To demonstrate full interoperability and security of data, include different smart buildings or smart communities platform solutions, developed by different technology providers.
- Include public entities in different sectors (i.e.: education, health, governance) that will participate in the demonstrators with their buildings and include home appliances producers in case of buildings.
- Analyse the social acceptance of citizens taking part to the experimentation towards the adopted technical solutions. Provide suggestions for wide adoption of the proposed solutions in different social contexts.

In addition, the PPCs that were described in the IP 2021-2025 and still need to be funded are presented in the next table. Description of the PPCs and the analysis can be found in the Annexes.

Table 5: PPCs that were described in the IP 2021-2025 and still need to be funded

HLUC 1: Optimal Cross sector Integration and Grid Scale Storage	HLUC 2: Market-driven TSO–DSO–System User interactions	HLUC 3: Pan European Wholesale Markets, Regional and Local Markets	HLUC 4: Massive Penetration of RES into the transmission and distribution grid	HLUC 5: One stop shop and Digital Technologies for market participation of consumers (citizens) at the centre	HLUC 6: Secure operation of widespread use of power electronics at all systems levels	HLUC 7: Enhance System Supervision and Control including Cyber Security	HLUC 8: Transportation Integration & Storage	HLUC 9: Flexibility provision by Building, Districts and Industrial Processes
PPC1.3 30M€	PPC2.1 16M€	PPC3.1 18M€		PPC5.3 28M€	PPC6.3 27M€	PPC7.2 27M€	PPC8.2 38M€	

ETIP SNET R&I **2025+**

PPC1.2 16M€	PPC2.2 28M€	PPC3.2 29M€	PPC 4.2 16M€	PPC5.4 18M€	PPC6.1 17M€	PPC7.4 28M€	PPC8.1 8M€	
	PPC 2.3 30M€	PPC3.3 20M€		PPC5.2 8M€	PPC6.4 4 M€	PPC7.1 19M€		
	PPC 2.4 5M€					PPC7.3 24M€		
TOTAL in M€ (for new PPCs of IP 2025+):								
46	79	67	16	54	48	98	46	0

ETIP SNET R&I **2025+**

Table 6: Fundings analysis in previous work programmes

Priority funding	Regularly funding	Slight increased funding
PPC2.2 = 28 M€	PPC1.3 = 30 M€	PPC1.2 = 16 M€
PPC2.3 = 30 M€	PPC2.1 = 16 M€	PPC2.4 = 5 M€
PPC3.2 =29 M€	PPC 3.1 = 18 M€	PPC4.2 = 16 M€
PPC6.3 = 27 M€	PPC3.3 = 20 M€	PPC5.2 = 8 M€
PPC7.2 =27 M€	PPC5.3 = 28 M€	PPC6.4 = 4 M€
PPC7.4 = 28 M€	PPC5.4 = 18 M€	PPC8.1 = 8 M€
	PPC6.1 = 17 M€	
	PPC7.1 = 19 M€	
	PPC7.3 = 24 M€	
	PPC8.2 = 38 M€	
SUM = 169	**SUM = 228**	**SUM = 57**

TOTAL = 454 M€

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Total Budget Needs for the ETIP SNET R&I Implementation Plan 2025+ (R&I project during period 2025-2028)

The budget suggestion for this Implementation Plan (IP) comprises two parts. The budget suggestion for the new PPCs and the budget suggestion for the PPCs that were included in the previous IP, but with insufficient funding. The detailed calculations for the latter are presented in the annexes, which are based on the Project Monitoring Report and the Horizon Europe Work Program 2023-2024.

Part 1: Budgets of 500 M€ for new, urgent PPCs (not yet previously defined in any ETIP SNET IP) in the R&I Project Period 2025-2028:

HLUC 1: Optimal Cross sector Integration and Grid Scale Storage	HLUC 2: Market-driven TSO–DSO–System User interactions	HLUC 3: Pan European Wholesale Markets, Regional and Local Markets	HLUC 4: Massive Penetration of RES into the transmission and distribution grid	HLUC 5: One stop shop and Digital Technologies for market participation of consumers (citizens) at the centre	HLUC 6: Secure - operation of widespread use of power electronics at all systems levels	HLUC 7: Enhance System Supervision and Control including Cyber Security	HLUC 8: Transportation Integration & Storage	HLUC 9: Flexibility provision by Building, Districts and Industrial Processes
PPC1.4 25M€	PPC2.5 35M€	PPC3.4 25M€	PPC4.5 25M€	PPC5.5 35M€		PPC7.5 25M€	PPC8.3 20M€	PPC9.4 20M€
PPC1.5 25M€	PPC 2.6 25M€		PPC4.6 25M€	PPC5.6 25M€		PPC7.6 25M€	PPC8.4 20M€	
	PPC2.7 35M€			PPC5.7 25M€		PPC7.7 25M€		
				PPC5.8 25M€		PPC7.8 35M€		

Part 2: Additional budgets of 454 M€ for PPC defined in the previous ETIP SNET IP 2022-2025, but not yet taken up by HE calls with sufficient budgets (for justification see Annexes I-IV)

HLUC 1: Optimal Cross sector Integration and Grid Scale Storage	HLUC 2: Market-driven TSO–DSO–System User interactions	HLUC 3: Pan European Wholesale Markets, Regional and Local Markets	HLUC 4: Massive Penetration of RES into the transmission and distribution grid	HLUC 5: One stop shop and Digital Technologies for market participation of consumers (citizens) at the centre	HLUC 6: Secure - operation of widespread use of power electronics at all systems levels	HLUC 7: Enhance System Supervision and Control including Cyber Security	HLUC 8: Transportation Integration & Storage	HLUC 9: Flexibility provision by Building, Districts and Industrial Processes
PPC1.3 30M€	PPC2.1 16M€	PPC3.1 18M€		PPC5.3 28M€	PPC6.3 27M€	PPC7.2 27M€	PPC8.2 38M€	
PPC1.2 16M€	PPC2.2 28M€	PPC3.2 29M€	PPC 4.2 16M€	PPC5.4 18M€	PPC6.1 17M€	PPC7.4 28M€	PPC8.1 8 M€	
	PPC 2.3 30M€	PPC3.3 20M€		PPC5.2 8M€	PPC6.4 4 M€	PPC7.1 19M€		
	PPC 2.4 5M					PPC7.3 24M€		

TOTAL Budgets of 954 M€ for all PPC for IP 2025+ (R&I project period 2025-2028)

HLUC 1: Optimal Cross sector Integration and Grid Scale Storage	**HLUC 2: Market-driven TSO–DSO–System User interactions**	**HLUC 3: Pan European Wholesale Markets, Regional and Local Markets**	**HLUC 4: Massive Penetration of RES into the transmission and distribution grid**	**HLUC 5: One stop shop and Digital Technologies for market participation of consumers (citizens) at the centre**	**HLUC 6: Secure - operation of widespread use of power electronics at all systems levels**	**HLUC 7: Enhance System Supervision and Control including Cyber Security**	**HLUC 8: Transportation Integration & Storage**	**HLUC 9: Flexibility provision by Building, Districts and Industrial Processes**
PPC1.3 30M€	PPC2.1 16M€	PPC3.1 18M€	PPC 4.2 16M€	PPC5.3 28M€	PPC6.3 27M€	PPC7.2 27M€	PPC8.2 38M€	PPC9.4 20M€
PPC1.2 16M€	PPC2.2 28M€	PPC3.2 29M€	PPC4.5 25M€	PPC5.4 18M€	PPC6.1 17M€	PPC7.4 28M€	PPC8.1 8 M€	
PPC1.4 25M€	PPC 2.3 30M€	PPC3.3 20M€	PPC4.6 25M€	PPC5.2 8M€	PPC6.4 4 M€	PPC7.1 19M€	PPC8.3 20M€	
PPC1.5 25M€	PPC 2.4 5M€	PPC3.4 25M€		PPC5.5 35M€		PPC7.3 24M€	PPC8.4 20M€	
	PPC2.5 35M€			PPC5.6 25M€		PPC7.5 25M€		
	PPC 2.6 25M€			PPC5.7 25M€		PPC7.6 25M€		
	PPC2.7 35M€			PPC5.8 25M€		PPC7.7 25M€		
						PPC7.8 35M€		

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ANNEXES

ANNEX I – The complete list of PPCs of the ETIP SNET R&I Implementation Plan 2022-2025 with R&I project funding needs.

This section provides the description of those PPCs from the IP 2022-2025 which have not been started by calls of the EC at all or where only parts have been taken up by EC calls in 2021/2022 and 2023/2024 or where funding in the HE calls have not been sufficient for achieving their goals.

The descriptions have the following sections:

- Type of PPC Action (IA/RIA)
- PPC Start/End Year
- Indicative PPC Budget
- Expected PPC Outcome
- Scope of PPC

PPC 1.1: Value of cross sector integration and storage

Type of Action: RIA	
Start/End Year: 2022-2027	**Indicative Budget:** 30M€

EXPECTED OUTCOME

- Projects should cover basic aspect for the cross-sector integration. Should provide support to EU policy for the following topics
- Develop models for optimisation of the operation and planning of the integrated energy systems, in order to facilitate cost effective transition to zero carbon energy future.
- Provide evidence related to the importance of cross-energy vectors coupling that would facilitate integration of large amount of RES and decarbonisation of heat / cooling, transport, industrial sectors.
- Develop a new market, regulatory and policy frameworks for delivering low-emission, low cost, secure, reliable and resilient whole-energy system
- Provides a holistic view and scientific guidance to foster technology and business model innovation to promote sustainable environmental and social circular economy objectives in energy storage and P2X, X2P, X2IndustrialService for an effective decarbonisation of the cross-energy sectors.
- Set targets according to established measurable KPIs for energy storage and P2X, X2P, X2IndustrialService

SCOPE

The projects should analyse the following topics:

- Role and value of cross sector Integration and energy storage under different future decarbonisation pathways according to both environmental and social sustainability dimension of the circular economy practices
- Assessment of cost and benefits of local versus national and international approach to cross-sector integration
- Role of large-scale energy storage (electricity, thermal, gas, hydrogen, etc.) in supporting cost effective decarbonisation and enhancing energy supply resilience
- Assessment of the benefits of providing system flexibility services by optimal cross-energy sectors integration according to established measurable KPIs for energy storage and P2X, X2P, X2IndustrialService
- Projects' assessment under dimensions of eco-design, life-time assessment, circular economy, sustainability

According to the Project Evaluation Report (Annex II) PPC 1.1 has been sufficiently covered by the completed and on-going projects. (80% covered by on-going projects).

PPC 1.2: Control and operation tools for multi-energy systems

Type of Action: IA	
Start/End Year: 2022-2027	**Indicative Budget:** 60M€

EXPECTED OUTCOME

- Development of the new design standards that would enable cross-sector integration.
- Demonstrate the ability of providing real time balancing and management of flexibility by cross-energy vector coordination including various P2X, X2P, grid scale energy storage technologies.

- Tools using multi objective optimisation for the operation of multi-energy systems.
- Development and demonstration of advanced technologies and control concepts /platform tools for multi-energy systems based on appropriate data exchange between different energy sectors in local, national and pan EU regions.
- Creation of incentives and mechanisms for non-electric sector participants in an integrated energy system
- ICT requirements and standards to collect, deliver and utilise data, including data from different energy sector, to enable efficient flexibility markets.

SCOPE

Development and demonstration of advanced technologies and control concepts /platform tools for multi-energy systems based on appropriate data exchange between different energy sectors in local, national and international regions

- According to the Project Evaluation Report (Annex II) PPC 1.2 has been covered to a certain extent by the completed and on-going projects, more R&I efforts are needed. (58% covered by on-going projects).
- According to the comparison of funding allocated at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 (ANNEX-III) this PPC requires some additional funding.

PPC 1.3: Smart Asset management

Type of Action: IA	
Start/End Year: 2022-2027	**Indicative Budget:** 40 M€

EXPECTED OUTCOME

- New approaches for managing critical assets based on probabilistic risk assessment and optimisation of maintenance planning.
- Common asset models for interpretation of the huge amount of data available from system monitoring and inspection.
- Techniques and tools to extract the maximum level of information and knowledge out of the data from the field, using advanced analytics, machine learning and Big Data technologies, to be applied using equipment ageing and failure models as well as system resilience evaluation tools.
- Solutions based on digital approaches (such as tablets, wearables, robotics, drones and other elements) to support asset management and intelligent management to increase system reliability, reduced the risk for workers, decrease OPEX.

SCOPE

The PPC addresses the advanced management of assets in the energy system along their entire lifecycle, from the commissioning to the end-of life covering the identification of the degradation phenomena and the indicators of the failure development, the sensors and methods for diagnostic and monitoring, the setting up of maintenance policies and end-of-life decision making at the light of the progressive advancement of data acquisition and management techniques.

Deployment of IoT sensors, communication, data management & analysis and feedback to control systems encompasses a huge number of devices and systems, so high TRL R&I actions are definitely needed.

According to the Project Evaluation Report (Annex II) 1.3 has been covered to a certain extent by the completed and on-going projects, more R&I efforts are needed. (50% covered by on-going projects).

PPC 2.1: Market models and architecture for TSO–DSO–System User interactions

Type of Action: RIA	
Start/End Year: 2022-2027	**Indicative Budget:** 20 M€

Expected Outcome

- Market design for DER and VPP participation
- Development and validation of Cost Benefit Analysis for TSO-DSO ancillary services coordination
- Increased participation of consumers and local communities
- Definition of standard pan-European ICT platforms to allow the interaction of the different actors in the process of acquisition of ancillary services (end-users/BSPs, market operators, TSOs, DSOs, aggregators and BRPs) in an integrated and optimised environment.

- Methodologies to optimise provision of Ancillary Services from distributed resources in the distribution network
- Market models for the interaction of TSOs and DSOs including interactions between central and local markets
- Assessment of Identify technical, market and business barriers to the smooth cooperation and interaction between TSOs, DSO and consumers
- Assessment of improvement paths in system operation to enable the integration of new services and products in system operation
- Demonstrate Demand Side participation, consumer involvement and Local Energy Communities
- Increase observability in the power system and allow data exchange between the DSOs and TSOs
- Specify appropriate technical characteristics and timeframes to participate in the markets
- Unlock markets of flexibility at every level to address the needs of the SOs. (Standardise balancing market data exchange vertically (across the electricity value chain) and horizontally (across vectors/sectors)
- Creation of incentives and mechanisms for non-electric sector participants in an integrated energy system

SCOPE

Definition of suitable market models for the interaction of TSOs and DSOs including interactions between central and local markets and across different time frames. Identification of technical, market and business barriers to the smooth cooperation and interaction between TSOs, DSO and System User. Provide evidence related to the benefits of market-driven options and solutions.

According to the Project Evaluation Report (Annex II) PPC 2.1 has not been sufficiently covered by the completed and on-going projects (23% covered by on-going projects).

PPC 2.2: Control and operation for enhanced TSO–DSO– System User interactions

Type of Action: IA	
Start/End Year: 2022-2029	**Indicative Budget:** 30 M€

EXPECTED OUTCOME

- Methods and tools for prosumer monitoring and participating in the markets
- ICT technologies enabling prosumer participation in the markets
- Standardise balancing market data exchange vertically (across the electricity value chain) and horizontally (across vectors/sectors
- Design and test efficient optimisation algorithms for near real-time TSO-DSO-Consumer coordination considering grid constraint.
- Identify universal devices needs for TSO-DSO information exchange at different time frames
- big data management and advanced algorithms solutions for supporting decision making by System Operators
- Improved real-time observability of RES
- Develop models for robust net load forecasting and robust forecasting of available flexibility.
- Assessment of technical, market and business barriers to the smooth cooperation and interaction between TSOs, DSO and consumers
- Ensure resilience contributions from DER (including black start)
- Design and test efficient optimisation algorithms for near real-time TSO-DSO-Consumer coordination considering grid constraint
- Ensure and test overall dynamic stability
- Improve/deploy and demonstrate IoT and EMS at System User premises to optimise (self)consumption and market participation according to grid needs and/or market signals (intelligent agents)
- Design and test optimal utilisation and control of Demand Side Response by TSOs and DSOs

SCOPE

The projects should analyse the following aspects:

- Design, development and demonstration of effective control mechanisms and technologies for System User participation in the market
- Optimisation of the operation of the energy system and the provision of Ancillary Services from distributed resources, ensuring resilience contributions from DER
- Development and improvement of digital technologies to support customers and distributed energy resources to participate in the operation and market
- Use of advanced analytics and big data management for decision-making
- Real time balancing and management of flexibility

According to the Project Evaluation Report (Annex II) PPC 2.2 has not been sufficiently covered by the completed and on-going projects (12% covered by on-going projects).

PPC 2.3: Platform development for TSO/DSO cooperation	
Type of Action: IA	
Start/End Year: 2022-2029	**Indicative Budget:** 30 M€

EXPECTED OUTCOME

- Design data exchanges and standard protocols for all players paving the way for a cross-sector approach
- test platforms and mechanisms usage for cooperation (between System Operators, and between SOs and consumers).
- Develop and improve digital technologies (e.g., protocols, devices) to support customers and distributed energy resources to participate in the operation and market.
- Leverage the use of standards for data exchange of data (CGMES, CIM, etc). Definition of appropriate data models that can represent properly all the TSO-DSO- System User interactions.
- Develop and demonstrate effective and efficient platforms for market-driven interactions between multiple players that are interoperable and that fits the market requirements and have flexible interfaces

SCOPE

Design and development of platforms for an effective information sharing, allowing access and cooperation from multiple energy system players and an efficient organisation of the energy system

According to the Project Evaluation Report (Annex II) PPC 2.3 has not been sufficiently covered by the completed and on-going projects (38% covered by on-going projects).

PPC 2.4: Planning Tools for TSO-DSO cooperation	
Type of Action: RIA	
Start/End Year: 2022-2031	**Indicative Budget:** 10 M€

EXPECTED OUTCOME

- Efficient long-term planning and corresponding tools and simulation capabilities
- stimulate participation from cross-sector actors
- Expand TSO-DSO cooperation towards the network planning longer timeframe
- Identify and validate mechanisms for Gas TSO and Gas DSO cooperation in managing pipe pressures and consumer requirements in the context of increasing alternative gases (e.g., hydrogen)
- Ensure and test overall dynamic stability

SCOPE

Optimise the planning of the energy system. Development of efficient long-term planning and corresponding tools and simulation capabilities, including local and global dimensions and allowing multiple System User typologies and aggregations

According to the Project Evaluation Report (Annex II) PPC 2.4 has not been sufficiently covered by the completed and on-going projects (20% covered by on-going projects).

PPC 3.1: Fundamental market design	
Type of Action: RIA	
Start/End Year: 2022-2029	**Indicative Budget:** 25 M€

EXPECTED OUTCOME

- Enable development of operation of short term (seconds-minutes-hours) fully decentralised energy markets including stability, balancing and energy exchange, while managing network congestions
- Develop fundamentally new multi-energy market with appropriate temporal and special spatial granularity to facilitate cost effective transition to low carbon energy future.
- Develop cost effective market mechanism for allocation of costs related to the provision of balancing services, network charging, investment in conventional and low carbon generation.

• Demonstrate that the new market will enable flexibility technologies and advanced system control concepts to access revenues associated with all benefits delivered. • Develop fully decentralised energy markets including peer-to-peer trading of energy and balancing services, while maximising service quality delivered to end consumers
SCOPE The projects should analyse the following aspect: • Assessment of the need to coordinate market clearing process for balancing services covering different timescales (second, minutes, hours) while considering the conflicts and synergies between local district and national, international objectives. • In the context of EU wide market, develop appropriate market design that would enable optimal exchange of energy and balancing services by interconnectors. • Energy market design that would recognise option value of flexibility technologies dealing with uncertainties in future deployment of low carbon technologies in local, regional EU wide areas. • Market design that recognises uncertainties in the provision of alternative balancing / ancillary services by different technologies (establishing level playing approach for the provision of services across different service delivery concepts /technologies) • Assess the value of flexible distributed energy resources, such as demand side response, domestic batteries and batteries in electric vehicles, thermal energy storage etc., in offering flexibility and balancing services to the grid through aggregation
According to the Project Evaluation Report (Annex II) PPC 3.1 has been covered to a certain extent by the completed and on-going projects, more R&I efforts are needed. (50% covered by on-going projects).

PPC 3.2: Regulatory framework and strategic investments	
Type of Action: RIA	
Start/End Year: 2022-2029	**Indicative Budget:** 30 M€
EXPECTED OUTCOME • Develop Market design / regulatory framework for supporting cost effective delivery of security and resilience of supply from local to national / international level. • Enhance renewable power purchase agreements • Guarantees of origin are a key tool for consumer information as well as for the further uptake of renewable power purchase agreements. • Develop market design / regulatory framework for supporting cost effective delivery of security and resilience of supply from local to national / international level	
SCOPE The projects should analyse the following topics: • Development of fundamentally new concept for efficient allocation of cost related to the provision of all ancillary /balancing services, network congestion management, provision of security of supply and meeting carbon targets cost effectively. • Market design / regulatory framework for supporting cost effective delivery of security and resilience of supply from local to national / international level • Design of market / regulatory framework that would support strategic investment in energy infrastructure when/where appropriate (e.g. investment in reinforcement of electricity distribution network infrastructure in order to support cost effective and timely electrification of transport sector, strategic investment in offshore infrastructure to integrate offshore wind support system adequacy etc).	
According to the Project Evaluation Report (Annex II) PPC 3.2 has not been sufficiently covered by the completed and on-going projects (17% covered by on-going projects).	

PPC 3.3: IT systems for cross-border trading	
Type of Action: RIA	
Start/End Year: 2022-2029	**Indicative Budget:** 25 M€

<table>
<tr><td colspan="2">EXPECTED OUTCOME
Simulation analysis with new technologies; real-time analysis of new technologies with extensive power electronics; use of HIL (HW in the loop) simulation to validate new technologies; simulation at local level, national level, cross-border level and pan-European effects; preparation for risk-controlled field demonstrations.
Validated tools and solutions for the management of the Pan-European transmission network, for secure operation of the power system with steadily increasing (beyond 100% of demand during certain intervals) inverter-based RES, through fast real-time and continuous prediction of dynamic stability margins and preventive mechanisms and the market-based activation of cross-border dynamic stability services (such as ancillary services)</td></tr>
<tr><td colspan="2">SCOPE
An integrated EU energy market needs to be a priority, to ensure secure and affordable energy supplies to European citizens and businesses: therefore, common energy market rules, communication standards and protocols and cross-border infrastructure need to be designed and established.</td></tr>
<tr><td colspan="2">According to the Project Evaluation Report (Annex II) PPC 3.3 has been covered to a certain extent by the completed and on-going projects, more R&I efforts are needed. (50% covered by on-going projects).</td></tr>
</table>

<table>
<tr><th colspan="2">PPC 4.1: Technical barriers and technical measures for integration of RES at multiple levels and sectors</th></tr>
<tr><td>Type of Action: RIA</td><td></td></tr>
<tr><td>Start/End Year: 2022-2029</td><td>Indicative Budget: 20 M€</td></tr>
<tr><td colspan="2">EXPECTED OUTCOME
Analysis of re-dispatch process and efficient market solutions
Friendly Market design for RES participation (short-term bids)
Improved modelling and simulation
Facilitate the participation of cross-sector RES
Reduce system risks associated with increased fluctuating generation
Assessment market dynamics</td></tr>
<tr><td colspan="2">SCOPE
Creating the conditions for effective participation of industrial, residential, communities from multiple sectors and for deploying of corresponding grids leading to an increased share of RES in the energy system. Ensure the efficient and reliable connection and integration of large RES generation (e.g., large offshore grids).

Identify the technical barriers which may limit the ability of the power systems to accommodate further volumes of variable RES.

Creating the conditions for the effective participation of industrial, residential actors and energy communities and for deploying corresponding grids leading to an increased share of RES in the energy system.</td></tr>
<tr><td colspan="2">According to the Project Evaluation Report (Annex II) PPC 4.1 has not been sufficiently covered by the completed and on-going projects (25% covered by on-going projects).</td></tr>
</table>

<table>
<tr><th colspan="2">PPC 4.2: Control and operation tools for a RES based energy system</th></tr>
<tr><td>Type of Action: IA</td><td></td></tr>
<tr><td>Start/End Year: 2022-2027</td><td>Indicative Budget: 50 M€</td></tr>
<tr><td colspan="2">EXPECTED OUTCOME
Improved forecast tools
Transmission Network: Increase RES hosting capacity of Transmission System, expansion of the offshore grid
Distribution Network: Increase RES hosting capacity of Distribution System</td></tr>
</table>

- Technologies for distribution Grid operation exploiting Flexibility and Storage management and corresponding coordination with system operators
- Ensure efficient and effective DER control and Hybrid Power Systems
- Efficient mechanisms reduce system risks associated with increased fluctuating generation
- Efficient digital mechanisms for RES integration and participation (e.g., protocols, platforms
- Efficient curtailment mechanisms, with increased renewables and from multiple sectors

SCOPE

Design and test advanced technologies and control mechanisms for integrating massive volumes of RES at distribution and transmission level, handling network constraints and providing flexibility needs, ensuring coordination throughout energy sectors

According to the Project Evaluation Report (Annex II) PPC 4.2 has been sufficiently covered by the completed and on-going projects (63% covered by on-going projects).

PPC 4.3: Infrastructure requirements and network technologies as solutions for integration of massive RES	
Type of Action: IA	
Start/End Year: 2022-2029	**Indicative Budget:** 50 M€

EXPECTED OUTCOME

- Develop advanced network technologies, such as FACTS, WAMS
- Protections and Control
- Solutions to deal with lack of inertia
- Methodologies to manage energy transits in the networks
- Appropriate forecast (load, generation, transits)
- Multinational interconnection design to support offshore wind Optimal Flexibility Management including Demand Response

SCOPE

Ensure the integration of massive RES at multiple voltage levels through advanced networking solutions (e.g., HVDC, FACTS) and increasing flexibility capabilities from RES and grids

Ensure the efficient and reliable connection and integration of large RES generation (e.g., large offshore grids).

According to the Project Evaluation Report (Annex II) PPC 4.3 has been covered to a certain extent by the completed and on-going projects, more R&I efforts are needed. (43% covered by on-going projects).

PPC 4.4: Planning for a resilient system with massive penetration of RES	
Type of Action: RIA	
Start/End Year 2022-2031	**Indicative Budget:** 25 M€

EXPECTED OUTCOME

- Adequate modelling and simulation capabilities.
- Planning and Operating methods that aim at increased RES participation with increased resilience; Improved modelling and simulation

SCOPE

Enhance system resilience in the presence of increased RES penetration at all levels, via sophisticated forecast methods, models and techniques, simulation, restoration mechanisms, ensuring stability of the system and robustness to extreme events

According to the Project Evaluation Report (Annex II) PPC 4.4 has been covered to a certain extent by the completed and on-going projects, more R&I efforts are needed. (50% covered by on-going projects).

PPC 5.1: Value of consumer/customer acceptance and engagement	
Type of Action: IA	
Start/End Year: 2022-2027	**Indicative Budget:** 20 M€

EXPECTED OUTCOME

- Guidelines for the participation of prosumers and energy communities in electricity markets
- Guidelines for the implementation of incentives by dynamic prices, regulated tariffs and other market incentives.
- Software tools to automatically calculate flexibility of different assets and trigger demand response campaigns
- Remuneration software tools, based on energy retail and market prices

SCOPE

The scope of this PPC is to analyse the requirements of the platform that will accelerate the adoption of new energy services and technologies. The access to data and energy services will allow the customer to go beyond the electricity sector into fully integrated energy system.

According to the Project Evaluation Report (Annex II) PPC 5.1 has not been sufficiently covered by the completed and on-going projects (25% covered by on-going projects).

PPC 5.2: Plug and play devices and IoT (Internet of things) including security by design	
Type of Action: IA	
Start/End Year: 2022-2027	**Indicative Budget:** 30M€

EXPECTED OUTCOME

- Real plug&play situation for customer assets and data exchange
- Provision of access to the consumer to energy data and advanced services
- Facilitation of customers can easily join and change service providers
- Applications devices for putting the end user in direct contact with supplier, distributor and other involved market stakeholders.
- Availability of software to provide services to increase consumer satisfaction based on IoT.
- Development of robust and low-cost application of digital technology for peer-to-peer interactions (blockchain)
- Implementation of software tools for enhanced cooperative energy services increasing community's resilience and self-sufficiency.
- Design of ICT architectures for mass data communication and processing (Blockchain, Exchange Platforms)
- Design of efficient data and information management mechanisms for platforms integration in the energy system, from consumer related platforms to system operation platforms

SCOPE

One of the obstacles for customer to have a more active role in the energy system is the lack of solutions that really support plug and play. Purpose of this PPC is to remove this barrier and develop solutions that facilitate joining any kind of energy market across Europe.

According to the Project Evaluation Report (Annex II) PPC 5.2 has not been sufficiently covered by the completed and on-going projects (39% covered by on-going projects).

PPC 5.3: Utilisation of communication networks including cyber security	
Type of Action: IA	
Start/End Year: 2022-2029	**Indicative Budget:** 40M€

EXPECTED OUTCOME

- Advanced intrusion detection and prevention systems for energy infrastructures using security-related big data and deep learning methods.

- Advanced technologies and tools for the implementation of a proactive and anticipatory security strategy supporting threat hunting in integrated and federated Security Operation Centres (SOCs). New technologies for future SOCs are related to security monitoring, threat detection and response.
- Mechanisms of exploitation of common infrastructures such as 5G networks.

SCOPE

Smart solutions will use a variety of connection solutions. It is critical to facilitate connection while preserving security. This PPC will investigate how security by design can support use of private networks in energy applications.

According to the Project Evaluation Report (Annex II) PPC 5.3 has been covered to a certain extent by the completed and on-going projects, more R&I efforts are needed. (50% covered by on-going projects).

PPC 5.4: Cross-sectorial flexibility use cases	
Type of Action: IA	
Start/End Year: 2022-2027	**Indicative Budget:** 30M€

EXPECTED OUTCOME

- Consolidated ICT vision and strategy for common data acquisition processes for TSO-TSO, TSO-DSO, TSO-BSP (Balancing Service Provider) and TSO-SGU (Significant Grid User) data exchange corresponding to the expected targets for future market design, system development and operation.
- An integrated framework of interoperable systems, fed by multiple data sources from different sectors and with automatised learning and updating processes, implemented in day-by-day TSO processes able to represent near real-time power system status and maintenance and working conditions of the grid assets.
- Methods and algorithms for secure and comprehensive data collection across all energy sectors and for providing a more transparent and timely data access for decision making to all market participants (by exploiting new technologies such as IoT, Big data and AI).
- Design of efficient data and information management mechanisms for platforms integration in the energy system, from consumer related platforms to system operation platforms

SCOPE

Intrinsic flexibility of the electrical loads is rather limit. Linking different sectors is possible to reach unexplored options. This means not only multi-energy use cases but also links to other sectors not directly related to energy.

According to the Project Evaluation Report (Annex II) PPC 5.4 has not been sufficiently covered by the completed and on-going projects (25% covered by on-going projects).

PPC 6.1: Control solutions for next generation PV and battery inverters	
Type of Action: IA	
Start/End Year: 2022-2029	**Indicative Budget:** 30M€

EXPECTED OUTCOME

- New control methods are needed to exploit power electronics-based generation to play a central role in the network system
- New modelling methods are needed to better represent the new dynamics while the separation between electromechanical and electromagnetics eigenvalue will not be as clear as today.
- New methods and techniques are required to exploit the flexibility and controllability of these components and a new fundamental approach is needed to define how these devices are part of the system level control.

SCOPE

This PPC will develop control solutions for components such as PV and Battery inverters that can be considered grid friendly, i.e., able to variety of services that can be used at system level. The goal is standard the interface and deployment of such services to facilitate a future based on plug&play solutions

According to the Project Evaluation Report (Annex II) PPC 6.1 has not been sufficiently covered by the completed and on-going projects (33% covered by on-going projects).

PPC 6.2: Hybrid transmission/distribution and hybrid distribution AC/DC grids	
Type of Action: IA	
Start/End Year: 2022-2029	**Indicative Budget:** 30M€

EXPECTED OUTCOME

- Deployed holistic architectures which include hybrid AC/DC systems, smart transformers, energy routers and web of cells
- Energy router: Developing innovative and intelligent solutions to enable energy transfer (routing) between various AC and DC networks, also considering energy storage means, in order to increase flexibility, renewable sources (RES) integration and resilience of energy communities.

SCOPE

This PPC will develop the necessary control solution that support the development of hybrid grids in HV and MV. Goal is not to focus on new topology but on the development of the proper concepts that support interoperability and cooperation between converters operating in the DC and in the AC section of the system

According to the Project Evaluation Report (Annex II) PPC 6.2 has been covered to a certain extent by the completed and on-going projects, more R&I efforts are needed. (50% covered by on-going projects).

PPC 6.3: Next generation distribution substation	
Type of Action: IA	
Start/End Year: 2022-2029	**Indicative Budget:** 30M€

EXPECTED OUTCOME

- Smart transformers providing flexible connection between MV and LV AC networks and enabling AC and DC microgrids at LV level
- Methods to facilitate portion of the distribution grid to work in islanding mode coordinated at substation level (AM)

SCOPE

This PPC will explore all the possible integration of power electronics in the substation or close to the substation to develop the concept of a flexible and programmable power grid in which the substation is a centre of intelligence that facilitate the optimal power routing

According to the Project Evaluation Report (Annex II) PPC 6.3 has not been sufficiently covered by the completed and on-going projects (25% covered by on-going projects).

PPC 6.4: Simulation methods and digital twins at distribution and transmission level for power electronics driven networks	
Type of Action: IA	TRL
Start/End Year: 2022-2029	**Indicative Budget:** 10M€

EXPECTED OUTCOME

- Simulation analysis with new technologies; real-time analysis of new technologies with extensive power electronics; use of HIL (HW in the loop) simulation to validate new technologies; simulation at local level, national level, cross-border level and pan-European effects; preparation for risk-controlled field demonstrations
- Simulation of DER-provided flexibility for Distribution, under various scenarios, considering Total Expenditure (TOTEX) approach
- Exploring the role and impact of existing and emerging ICT for grid observability and controllability; using co-simulation techniques able to simulate ICT impact in power systems to ensure a reliable digitisation of pan European system

SCOPE

The growing presence of power electronics is radically modifying the dynamics of the power grids. This PPC will tackle the need of the new simulation tools that go beyond the classical separation between phasor simulation and electromagnetic

According to the Project Evaluation Report (Annex II) PPC 6.4 has not been sufficiently covered by the completed and on-going projects (17% covered by on-going projects).

PPC 7.1: Next generation of TSO control room

Type of Action: IA	
Start/End Year: 2022-2029	**Indicative Budget:** 35M€

EXPECTED OUTCOME

- Innovative sensors for the monitoring of power systems with the aim of an increased observability at all voltage levels.
- Validated prototypes of ICT-platform for real-time communication and data exchange among European TSO's.
- Regional WAMS applications operational in TSO's control rooms
- Validated tools for real-time estimation of intrinsic power system parameters (damping, system inertia, short circuit power in critical nodes…).
- Demonstrated techniques for early identification of critical situations and for the real time stabilisation of interarea oscillations in low inertia systems.
- Integration of distribution grids and dispersed generation data into the set of TSOs observable systems.
- Full observability of the European transmission grid based on phasor measurement linear/hybrid state estimation.
- Scalable hierarchical observability methods and systems enabling the utilisation of monitoring data at different geographical scale in a coordinated manner.
- Consolidated operational ICT-platforms for real-time communication and data exchange among European TSO's

SCOPE

System level automation is supposed to evolve to cope with the distributed characteristics of the generation and the active role of the loads. This PPC will define new architecture and solutions for the control room of the future. This PPC should also coordinate the work with 7.2 for a coherent TSO-DSO cooperation.

Resilient cyber secure architectures

According to the Project Evaluation Report (Annex II) PPC 7.1 has not been sufficiently covered by the completed and on-going projects (0% covered by on-going projects).

PPC 7.2: Next generation of DMS (Distribution Management Systems)

Type of Action: IA	TRL
Start/End Year: 2022-2029	**Indicative Budget:** 35M€

EXPECTED OUTCOME

- Sensing technologies, automation and control methods integrated into monitoring, analysis and control architectures.
- Validated tools and software for the study of distribution grids with very low (no) inertia.
- Enhanced MV and LV supervision for distribution grids

SCOPE

With the evolving role of the DSO, also the architecture of the DMS is supposed to evolve and to consider new services and interfaces. This PPC will investigate new architectures and services for the DSO of the future. This PPC should also coordinate the work with 7.1 for a coherent TSO-DSO cooperation.

Resilient cyber secure architectures

According to the Project Evaluation Report (Annex II) PPC 7.2 has not been sufficiently covered by the completed and on-going projects (33% covered by on-going projects).

PPC 7.3: Next generation of measurements and GIS (Geographic Information System) for distribution grids	
Type of Action: IA	
Start/End Year: 2022-2029	**Indicative Budget:** 30M€

EXPECTED OUTCOME

- Scalable hierarchical observability methods and systems enabling the utilisation of monitoring data at different geographical scale in a coordinated manner.
- Innovative data processing architectures and methods that enable advanced solutions for the increasing complexity of system development and operations.
- Big data analysis functions of real-time data streaming for system operation.
- ICT architectures for mass data communication and processing (Blockchain, Exchange Platforms)
- Use Smart meters for accessing its data directly by multiple actors, while preserving GDPR and contractual clauses
- Test results and proof of concept of AI technologies applied to estimation of indicators and completion of information necessary to operate the system (control systems and interfaces for market participant applications, demand pattern recognition, ...).

SCOPE

Data fusion is one of the key topics in the process of digitalisation of power grids. This PPC will investigate the new type of data associated to new measurement devices but also to other sources of information such as GIS to improve planning and operation of distribution grids. This PPC will investigate how these different sources of data can be integrated in the processes in a smooth way improving the on-line capability of planning and operating of DSOs.

According to the Project Evaluation Report (Annex II) PPC 7.3 has been covered to a certain extent by the completed and on-going projects, more R&I efforts are needed. (42% covered by on-going projects).

PPC 7.4: Wide area monitoring, control and protections	
Type of Action: IA	
Start/End Year: 2022-2031	**Indicative Budget:** 35M€

EXPECTED OUTCOME

- Scalable hierarchical observability methods and systems enabling the utilisation of monitoring data at different geographical scale in a coordinated manner.
- Regional WAMS applications operational in TSO's control rooms
- On-line dynamic security assessment (voltage, frequency, angle) of interconnected power systems based on active distribution networks, inverter-based generation and loads acting as grid sensors and as integrated part of new network protection schemes

SCOPE

While Phasor Measurement Units have already emerged as a key measurement tool both at transmission and distribution level, the application in monitoring, control and protection that fully exploit the capability of the Wide Area approach are still limited. This PPC should develop innovative use cases to full exploit the potential of the technology.

According to the Project Evaluation Report (Annex II) PPC 7.4 has not been sufficiently covered by the completed and on-going projects (33% covered by on-going projects).

PPC 8.1: Technical and economic implication of decarbonisation of transport sector	
Type of Action: IA	
Start/End Year: 2022-2029	**Indicative Budget:** 30M€

EXPECTED OUTCOME

• Quantify the value of interoperability between energy and transport sectors and develop corresponding strategies for cost effective decarbonisation of both energy and transport sectors • Development of alternative decarbonisation strategies for transport sectors (electricity and hydrogen based) – (a) micro-mobility, public, fleet and private vehicles, (b) long on the ground transport (c) riverboats, sea-boats, (d) aviation • Deployment strategies for rapid-charging infrastructure considering the impact on the energy system, including application of energy storage and hydrogen-based resources for electricity production. • Development of full interoperability between energy and transport sectors through establishment of common standards, protocols and digital services. • The PPC is expected to contribute to 2Zero Partnership
SCOPE Asses alternative policy strategies for providing funding for decarbonisation of different transport sectors Assessing the whole-energy system implications of alternative strategies for decarbonisation of transport sectors, including the impact on investment cost of conventional and low carbon generation, network infrastructure reinforcement and system operating costs, while meeting the carbon targets. Assessment of the system value of smart electro mobility-based powertrain technologies (full electric vehicles, plug-in hybrids and hydrogen fuel cell-based vehicles), in providing control services at the local and national level through coordinated DSO/TSO control Assessment of the degradation of EV batteries when providing different V2G based system services and corresponding costs Assessment of the end-user perspective for different EV charging strategies, considering the costs and benefits related to provision of system services through smart EV charging and V2G Explore the viability of developing offshore charging facilities for sea boats/vessels supplied by offshore wind, considering the energy system impacts.
According to the Project Evaluation Report (Annex II) PPC 8.1 has not been sufficiently covered by the completed and on-going projects (38% covered by on-going projects).

PPC 8.2: Enhancing effectiveness of energy system operation and resilience with electromobility	
Type of Action: IA	
Start/End Year: 2022-2029	**Indicative Budget:** 70M€
EXPECTED OUTCOME • Application of the concept of V2X (Grid, Home and/or Business) and energy storage technologies for enhancing security and resilience of energy system	
SCOPE Assessment the benefits of smart control of different charging infrastructures in providing various system services through connecting EVs to IoT concept. Incorporation of uncertainties related to the provision of services by transport sector, specifically considering V2G concept from private, fleet and public vehicles Assessment of the V2X based enhancement of resilience of supply in local areas, through making use of batteries in busses, taxies and fleet vehicles and energy storage technologies Assessment of the benefits of fast-charging stations in providing security services to local district and national infrastructure	
According to the Project Evaluation Report (Annex II) PPC 8.2 has been covered to a certain extent by the completed and on-going projects, more R&I efforts are needed.(50%)	

PPC 9.1: Value assessment of the integration of buildings, infrastructure and smart communities in a RES based energy system	
Type of Action: IA	
Start/End Year: 2022-2027	**Indicative Budget:** 20M€

EXPECTED OUTCOME

- Inclusive market design
- Elaborate energy models and validate economic benefits
- Efficient sector integration
- Effective participation of multi-sector buildings
- Market participation related aspects: (pre-) qualification, communication, bid mechanisms
- Integration of Efficient carbon-neutral buildings
- Integration of building flexibility in distribution network operation
- Integration of Local Energy Communities, Districts and Smart Cities
- Improved flexibility assessment and forecast
- Integration of aggregated demand in the wholesale energy market and in the frequency ancillary services market
- Development of more accurate user profiles for holistic management of buildings
- The PPC is expected to contribute to Built4People Partnership

SCOPE

Creating the conditions for effective integration of renewable generation from multiple sectors in buildings and other individual or aggregated infrastructures leading to an increased share of RES in the energy system supported on digitalisation

According to the Project Evaluation Report (Annex II) PPC 9.1 has been covered to a certain extent by the completed and on-going projects, more R&I efforts are needed. (43% covered by on-going projects).

PPC 9.2: Control and operation tools for the integration of buildings and smart communities	
Type of Action: IA	
Start/End Year: 2022-2029	**Indicative Budget:** 50M€

EXPECTED OUTCOME

- Efficient heating and cooling for buildings, districts and industries
- Efficient Management of Thermal Storage
- Design and test adequate control mechanisms and ICT enables for integration of RES in buildings (namely H&C) and buildings integration in the energy system
- Methods and tools to support prosumers and industries to adapt behaviours (measurements, dynamic tariffs)
- Provision of flexibility from buildings (including thermal storage) and smart communities to system operators
- ICT related aspects: connection of buildings to the power system, communication requirements Integration of heterogeneous flexibility in one platform
- Test flexibility from energy-intensive industries
- Resilience support to the grid and system (e.g., extreme events)
- Microgrid efficient integration
- Develop flexibility mechanisms (support to System Operators) from building level to Community and Smart City level
- Integration of VPP/VPS (logic aggregation of demand/prosumers)
- Use AI and digital twins for demand flexibility assets
- Peer-2-peer mechanisms
- Effective Home Energy Management System (HEMS) – monitoring and control
- Exchange of information with HEMS
- ICT related aspects: connection of buildings to the power system, communication requirements
- Integration of heterogeneous flexibility in one platform
- Device monitoring and control, seamless communication between devices, communications, demand response, data management, security and privacy, consumer interface, EV integration, centralised vs distributed management
- Interfaces with DSO and ESCOs

SCOPE
Design and test advanced control methods and enabling technologies to integrate multi-sector generation, ensuring the provision of needed flexibility from individual or aggregated heating and cooling networks, buildings, local communities, benefiting from energy system digitalisation Demonstrate effective and efficient management (e.g., via HEMS and BMS) of connected and stand-alone (island) buildings, living quarters, businesses and industries, communities supplied by RES, enabling sector coupling and storage components (P2X, X2P)
According to the Project Evaluation Report (Annex II) PPC 9.2 has been sufficiently covered by the completed and on-going projects (60% covered by on-going projects).

PPC 9.3: Planning for resilient integration of buildings and infrastructures in an integrated energy system	
Type of Action: IA	
Start/End Year: 2022-2029	**Indicative Budget:** 30M€
EXPECTED OUTCOME • Stabilisation of weak grids and microgrids • (Intended) Islanding mode of operation • Black start capabilities • Improved forecasting (including behind-the-meter aspects) • Net load forecasting • Aggregated forecasting	
SCOPE Design and test energy models with multi-sector buildings, infrastructures and communities, through enhanced forecasting and analytics techniques and understanding of behaviour of individual and aggregated loads and local generation, ensuring resilient integration of multiple infrastructures, including microgrids, VPPs and VPSs and resulting grid stability Enable and demonstrate the contribution of distributed infrastructures and communities to the system resilience, recovery and robustness throughout extreme events, both cyber and physical	
According to the Project Evaluation Report (Annex II) PPC 9.3 has not been sufficiently covered by the completed and on-going projects (33% covered by on-going projects).	

ANNEX II – Results of Project Monitoring Report 2023 – Coverage of expected outcomes of PPCs, defined in ETIP SNET IP 2022-2025

The following figure summarises the key findings of the Project Monitoring Report. Specifically, it highlights the contributions made by ongoing research projects towards the PPCs, as described in the previous IP2021-2023.

The figure adopts a color-coded scheme to represent the coverage level of each PPC:

- ≥ 60% (green): Signifies that the PPC is sufficiently covered by the ongoing research projects. However, it may be necessary to consider more specific contributions in future calls to further enhance the coverage and address any remaining gaps.
- ≥ 40% and < 60% (yellow): Indicates that the PPC is partially covered by the ongoing research projects. While some progress has been made, there is room for additional efforts to achieve a more comprehensive coverage.
- < 40% (red): Indicates that the PPC is not sufficiently covered by the ongoing research projects. This signifies that additional funding is required to fulfill the expected outcomes of these PPCs as outlined in the previous IP.

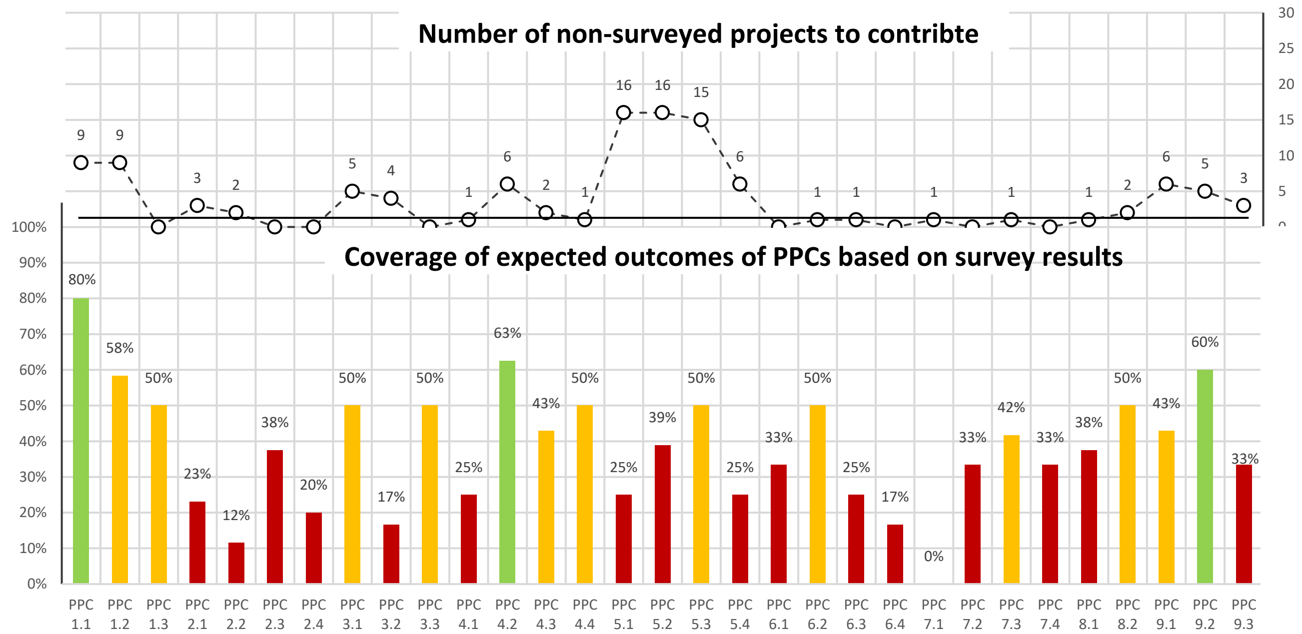

Figure 2. Total indicated and expected contributions to HLUCs

This analysis indicates the additional funding required so that the expected outcomes of the PPCs defined in the previous IP are successfully completed. It should be noted that although these results provide a clear indication of the PPCs needing additional R&I efforts, the following should be considered:

- The results are based on the answers of the project coordinators, as collected via a dedicated questionnaire. The interpretation of the HLUCs and PPCs might not be uniformly understood;
- Only 55% of the recently completed or on-going projects have responded to the questionnaire. Some effort has been made to allocate the rest of projects to the PPCs based on their descriptions;
- Overlap between the different PPCs is unavoidable. So, some specific tasks that are considered missing might be covered in other relevant PPCs;
- The results do not include the project calls within the Horizon Europe 2023-2034 calls. Thus, PPCs that present low progress in Figure 2 (marked in red) might be covered in on-going calls.

ANNEX III - Comparison between HLUC FUNDING ALLOCATED at the Horizon Europe 2023-2024 WP and the ETIP SNET IP 2022-2025 budgets

The analysis of the calls within Cluster 5 of the Horizon Europe Work Program 2023-2024 focusing on budget allocation per HLUC is shown in Table 7.

Table 7: Analysis of the calls within Cluster 5 of the Horizon Europe Work Program 2023-2024 focusing on budget allocation per HLUC

HE Call ID	HLUC1	HLUC2	HLUC3	HLUC4	HLUC5	HLUC6	HLUC7	HLUC8	HLUC9
HORIZON-CL5-2023-D3-01-18	20%		20%				20%	20%	20%
HORIZON-CL5-2023-D3-01-01,				50%	50%				
HORIZON-CL5-2023-D3-02-13:				100%					
HORIZON-CL5-2023-D3-02-14:				80%		20%			
HORIZON-CL5-2023-D3-01-03:				100%					
HORIZON-CL5-2023-D3-01-05:				100%					
HORIZON-CL5-2024-D3-02-08:				60%	40%				
HORIZON-CL5-2024-D3-02-10:				100%					
HORIZON-CL5-2023-D3-01-15					100%				
HORIZON-CL5-2024-D3-01-11:					100%				
HORIZON-CL5-2023-D3-01-11						80%		20%	
HORIZON-CL5-2023-D3-01-12:						100%			
HORIZON-CL5-2024-D5-01-04:						50%		50%	
HORIZON-CL5-2024-D5-01-14:						50%		50%	
HORIZON-CL5-2023-D3-03-06:				50%		50%			
HORIZON-CL5-2023-D3-01-13	40%					60%			
HORIZON-CL5-2023-D2-01-05	50%			10%	20%		20%		
HORIZON-CL5-2023-D3-02-06:	60%								40%

HORIZON-CL5-2023-D3-03-02	80%		10%	10%					
HORIZON-CL5-2023-D3-01-09	60%				40%				
HORIZON-CL5-2024-D3-01-12	20%			20%	40%				20%
HORIZON-CL5-2023-D3-01-10		40%					60%		
HORIZON-CL5-2023-D3-03-04		30%			70%				
HORIZON-CL5-2023-D3-03-05			30%		40%				30%
HORIZON-CL5-2024-D3-01-17						20%	80%		
HORIZON-CL5-2024-D3-02-05							100%		
HORIZON-CL5-2024-D5-01-01							100%		
HORIZON-CL5-2023-D3-03-03							100%		
HORIZON-CL5-2023-D3-01-02									100%
HORIZON-CL5-2023-D3-01-04	20%								80%
HORIZON-CL5-2024-D3-01-06	20%								80%
HORIZON-CL5-2023-D4-01-05									100%
HORIZON-CL5-2024-D4-01-02				20%					80%
HORIZON-CL5-2024-D3-02-06									100%
HORIZON-CL5-2023-D4-01-03			20%		20%				60%
HORIZON-CL5-2023-D4-02-01					30%				70%
HORIZON-CL5-2024-D4-02-05					40%				60%

This table is translated to the budget allocation among the HLUCs. Notably, higher budgets have been allocated to HLUC 4, 5, 6, and 9, indicating their prioritisation and the recognition of their potential impact within Cluster 5 of the Horizon Europe Work Program.

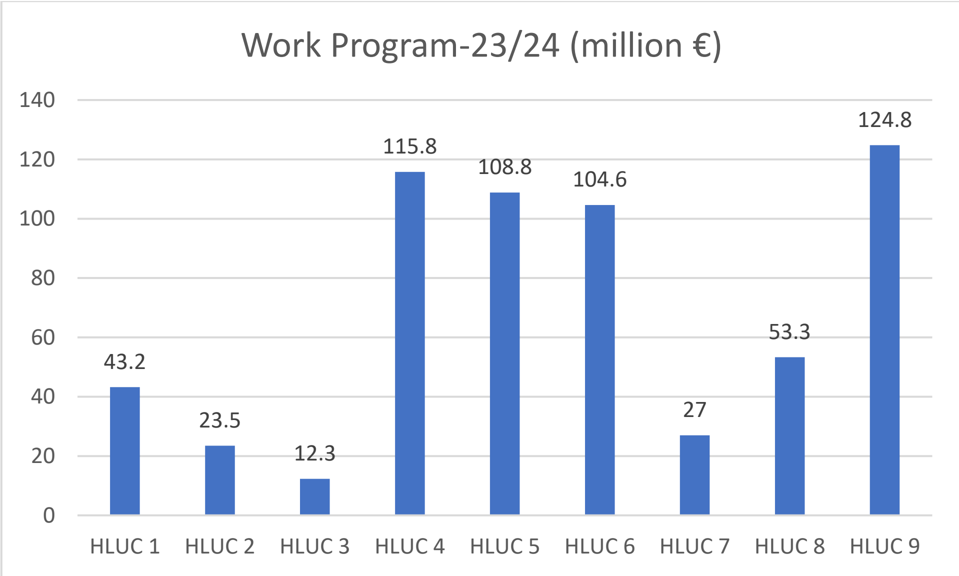

Figure 3. Budget allocation among HLUCs

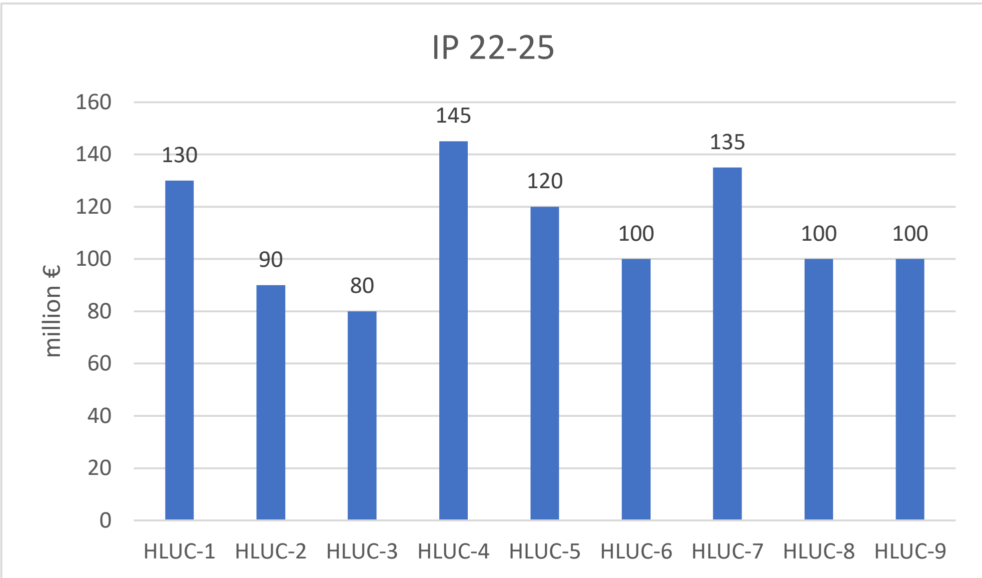

Figure 4. Budget allocation among HLUCs in the budget of IP 22-25

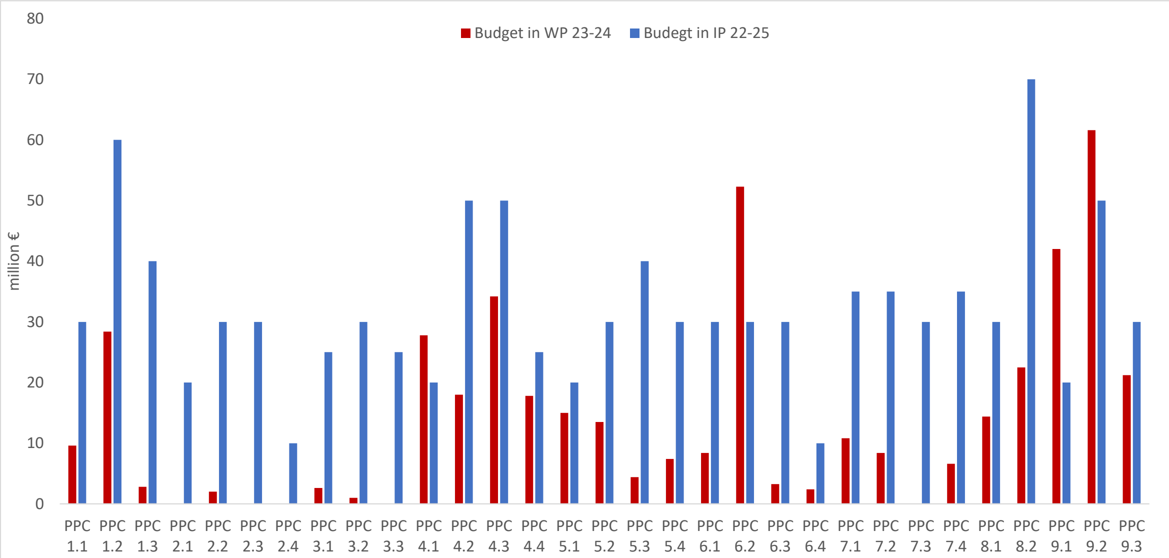

Figure 5. Comparison of Budget allocation among PPCs between IP 22-25 (blue) and WP23-24 (red) in million Euros

Figure 5 compares the budget allocation among PPCs between the WP 23-24 and the IP 22-25. This comparison is however relative, since it refers to different overall budgets and different durations. Another picture about the distribution of funding among the PPC is provided in Figure 6, where the budgets allocation is normalised over the total amounts of funding, as follows:

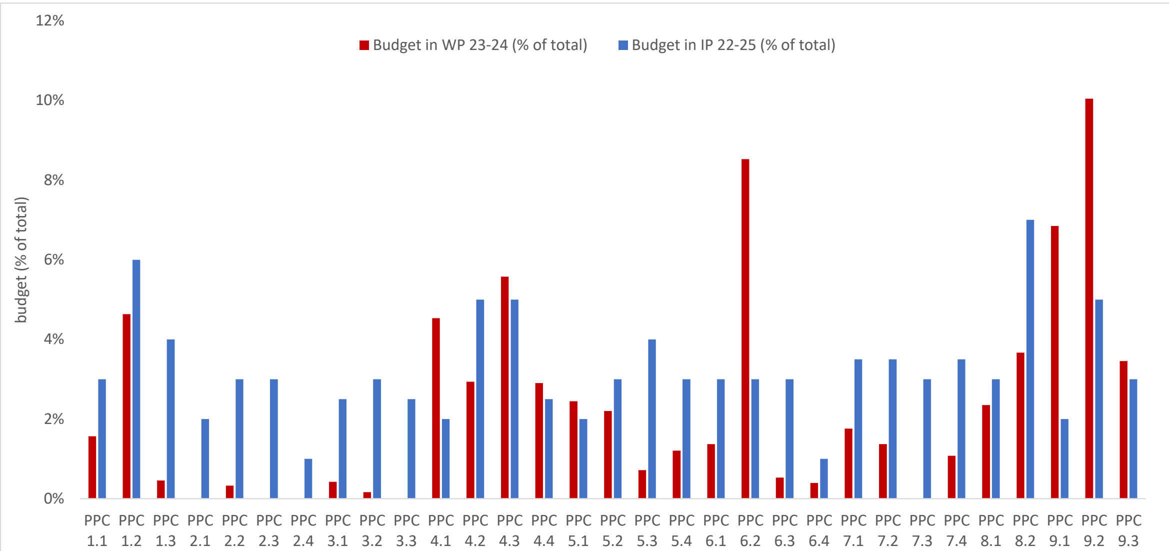

Figure 6. Comparison of Budget allocation among PPCs between IP 22-25 (blue) and WP23-24 (red) in %

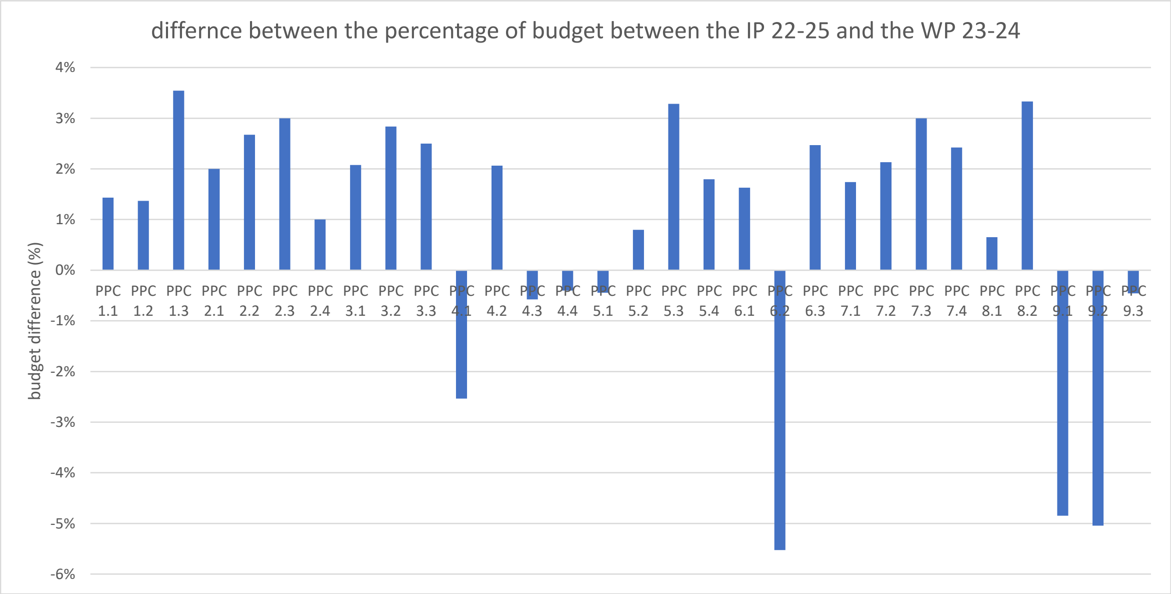

Figure 7. Differences between the percentage of budgets between the IP22-25 and the WP 23-24

Figure 7 presents the difference between IP 22-25 and the WP 23-24. When this difference is more than 2% it is concluded that this PPC was not adequately funded (mark red), if it is between 1% and 2% it requires some funding (mark orange), while if it is less than 1% or negative, it has been already well funded (mark green), as shown in Figure 8.

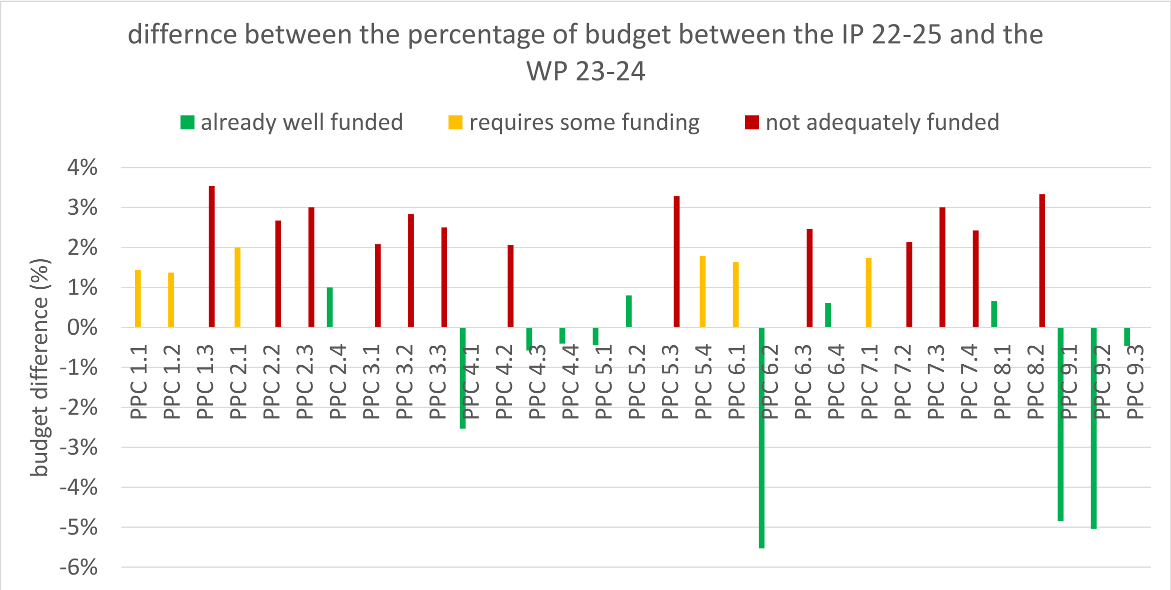

Figure 8. Significance of differences between the percentage of the PPC-related budgets between the IP 22-25 and the WP 23-24

Comparing the results of Figure 1 of Annex II with the results of Figure 8, the following Table can be derived. In the table, line 1 corresponds to Figure 2 in Annex II (Project monitoring report), representing a specific category P, O, N for each of the PPCs: 'P' stands for Positive (more than IP 22-25) Funding, 'N' represents Negative (less than IP 22-25) Funding, and 'O' denotes neutral funding.

Line 2 corresponds to Figure 8 (comparing IP 2022-2025 to HE WP 2023-24), indicating again categories P, O, N for each of the PPCs, now seen from the budget amount point of view.

Line 3 combines the information from the previous Line 1 and Line 2. Concluding, the '+' symbol in Line 3 indicates the need for prioritising funding of the respective PPCs.

Table 8: Comparison between Figure 2 Annex II and Figure 8

Line	PPC1.1	PPC1.2	PPC1.3	PPC2.1	PPC2.2	PPC2.3	PPC2.4	PPC3.1	PPC3.2	PPC3.3	PPC4.1	PPC4.2	PPC4.3	PPC4.4	PPC5.1	PPC5.2	PPC5.3	PPC5.4	PPC6.1	PPC6.2	PPC6.3	PPC6.4	PPC7.1	PPC7.2	PPC7.3	PPC7.4	PPC8.1	PPC8.2	PPC9.1	PPC9.2	PPC9.3
1	P	O	O	N	N	N	N	O	N	O	N	P	O	O	N	N	O	N	N	O	N	N	N	N	O	N	N	O	O	P	N
2	O	O	N	O	N	N	P	N	N	N	P	N	P	P	P	P	N	O	O	P	N	P	O	N	N	N	P	N	P	P	P
CONCLUDING INFORMATION from Lines 1 and 2 on more funding needs for PPCs defined in IP 2022-25.																															
3	P	O	N	N	N +	N +	O	N	N +	N	O	O	P	P	O	O	N	N	N	P	N +	O	N	N +	N	N +	O	N	P	P	O

More specifically, the results of Annex II (Project Monitoring Report) indicate which PPCs need more support in order to accomplish their expected outcomes based on the analysis of recently finished and on-going projects in the period 21-22. To complete the picture the funding allocated to each PPC within the Horizon WP 23-24 is compared with the budget allocation estimated at the corresponding IP 22-25. The comparison of these results shows which of the previous PPCs will need to be further supported in the current IP. These are shown below:

Priority Funding: PPC2.2, PPC2.3, PPC3.2, PPC6.3, PPC7.2, PPC7.4

Regular Funding: PPC1.3, PPC2.1, PPC 3.1, PPC3.3, PPC5.3, PPC5.4, PPC6.1, PPC7.1, PPC7.3, PPC8.2

Limited (slightly more) funding: PPC1.2, PPC2.4, PPC 4.2, PPC5.2, PPC6.4, PPC8.1

ANNEX IV - Overall renewed Budget Needs in the upcoming HE WP 2025 for PPCs defined in IP 2022-2025

Indicative budgets for the PPCs defined in the previous ETIP SNET IPs to be allocated in the current IP 2025+ are estimated from the difference in the budgets between the HE WP 23-24 and the ETIP SNET IP 22-25. This is shown in Figure 9 in million Euros.

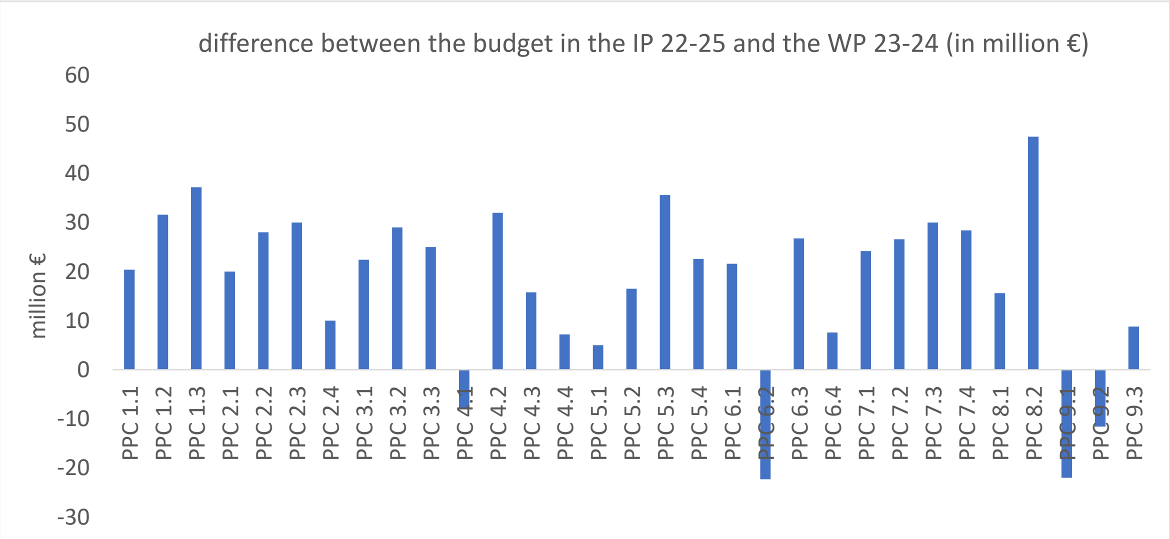

Figure 9. Difference in the budgets between the WP 23-24 and the IP 22-25

A positive number indicates that the desired funding defined in the IP 22-25 was not reached in the respective calls of the HE WP 23-24. A negative number (PPC 4.1, 6.2, 9.1, 9,2) indicates that funding of the HE WP 23-24 exceeded the figures as defined in the IP 22-2025.

Based on the above differences and the relative weights assumed for priority funded PPCs, regularly funded PPCs and slightly more funded PPCs, the following estimations can be made for the necessary funding (to be used in the upcoming HE WP 2025) for the PPCs defined in the previous ETIP SNET IP 2022-2025.

Table 9: Funding estimation

PPCs of IP 22-25 with Priority funding	PPCs of IP 22-25 with Regular funding	PPCs of IP 22-25 with Slightly increased funding
PPC2.2 = 28 M€	PPC1.3 = 30 M€	PPC1.2 = 16 M€
PPC2.3 = 30 M€	PPC2.1 = 16 M€	PPC2.4 = 5 M€
PPC3.2 =29 M€	PPC 3.1 = 18 M€	PPC4.2 = 16 M€
PPC6.3 = 27 M€	PPC3.3 = 20 M€	PPC5.2 = 8 M€
PPC7.2 =27 M€	PPC5.3 = 28 M€	PPC6.4 = 4 M€
PPC7.4 = 28 M€	PPC5.4 = 18 M€	PPC8.1 = 8 M€
	PPC6.1 = 17 M€	
	PPC7.1 = 19 M€	
	PPC7.3 = 24 M€	
	PPC8.2 = 38 M€	
SUM = 169 M€ **(priority funding)**	**SUM = 228** M€ **(regular funding)**	**SUM = 57** M€ **(slightly increased funding)**

TOTAL additional budgets (funding) for PPCs defined <u>in the previous IP</u> 2022-25 = 454 M€. This is in addition to the estimated 500 M€ budget needed for the new PPCs of this IP 2025+ which have not been defined in the previous ETIP SNET IP 2022-2025 (see chapter IV).

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