ETIP SNET

EUROPEAN TECHNOLOGY AND INNOVATION PLATFORM

SMART NETWORKS FOR ENERGY TRANSITION

ETIP SNET R&I Implementation Plan 2021-2024 – List of tasks

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Delivery date: 13 May 2020

The tasks indicated in the ETIP SNET R&I Implementation Plan 2021-2024 were developed in several iterations starting from a set of more than 400 tasks, from the previous ETIP SNET R&I Roadmap 2017-2026. ETIP SNET Stakeholders were strongly involved in the concatenation of these tasks, bringing them down to 261 tasks (the so-called 261 "Stakeholder tasks").

This list was further concentrated in 120 tasks, as presented on the next pages: for each task mentioned in the ETIP SNET R&I Implementation Plan 2021-2024, the link with the former 261 Stakeholders tasks is indicated in the column "Integrated Stakeholder tasks" together with the Functionalities and the expected TRL Maturity to be reached by the year 2024.

Full Task No	Tasks	Integrated Stakeholder tasks	Functiona-lities	24
1.1.1	1. Methods and tools for for the effective stakeholders engagement to increase **public acceptance of new energy infrastructures**, including transmission lines (overhead lines and underground cables), substations, storage facilities, generation stations (thermal and RES, like hydro, wind, etc.), gas pipelines and conversion stations, etc. (links to Social Science and Humanities)	1.1.1, 1.1.6, 1.1.9, 1.1.10,	F1, F2, F3, F5, F6, F7, F8, F10,	🟠
1.1.2	2. Increase consumer understanding and **awareness of new electricity/energy systems and** particularly the consumer/prosumer central role as active participants in grid operation. Investigate the social and economic impact of the **citizen involvement in forming energy communities**, including increased system resilience and sustainability.	1.1.2,	F3, F5, F6, F8, F10, F11, F12,	🔴
1.1.3	3. Studies to reduce or remove the **environmental impacts of energy infrastructures (visual, audible, etc.)**, e.g. for hydropower plants (hydropeaking effects, better sediment management, fish migration and fish protection, water quality, etc.), noise of transformers and transmission lines, more attractive designs for transmission line towers, changed visibility by undergrounding, etc.	1.1.3,	F2, F3, F5, F6, F7,	🟠
1.2.1	1. Methods and Tools to support **consumers' and prosumers' adaptation of energy behaviour**, including on-line measurements of electricity consumption and generation, dynamic time-of use tariffs and behavioural studies considering the full environment, such as non-energy benefits, like comfort and security.	1.2.1, 1.2.2, 1.2.3, 1.2.6, 1.2.7, 1.2.8, 1.2.9,	F3, F4, F5, F6, F7, F8, F10, F11, F12,	🟠
1.2.2	2. Methods and tools including campaigns to support the **industry's consumption adaptation** in order to support the system	1.2.7,	F3, F4, F10, F11,	🟠
1.3.1	1. **Wireless technologies for direct control** of prosumers' electricity consumption/generation using low-cost technologies (smart phones, etc.)	1.3.1,	F3, F5, F6, F10, F11,	🟠
1.3.2	2. In-home **ICT technologies for smart appliances** (e.g. smart load controllers) for direct control of consumer demand, incl. visualization via in-home displays.	1.3.2,	F3, F5, F6, F10, F11, F12,	🟠
2.1.1	1. Business models for **prosumers providing ancillary services**, including EV owners with bidirectional capabilities and storage units..	2.1.2, 2.1.4, 2.1.5, 2.1.7,	F2, F4, F5, F6, F7, F8, F9, F10, F11, F12,	🔴
2.1.2	2. Business models for **retailers and aggregators, ESCOs and energy communities**, providing energy efficiency at end-user level.	2.1.1, 2.1.4,	F3, F4, F5, F6, F7, F8, F10, F11, F12,	🔴
2.1.3	3. Business models for **data analysis service providers** to energy using large-scale data bases and advanced data-mining techniques	2.1.4,	F4, F5, F6, F7, F8,	🔴
2.1.4	4. Business models for **storage in electrical transportation networks** (e.g. tramways, trains, buses)	2.1.3,	F4, F5, F6, F8, F9, F10, F11, F12,	🔴

24: TRL-Maturity Year 2024

Red circle: Research (TRL 3-5)
Orange circle: Demonstr. (TRL 6-8)
Green circle: Deployment (TRL 9)

Full Task No	Tasks	Integrated Stakeholder tasks	Functiona-lities	24
2.1.5	5. Business models for **gas-fired or biomass fired CHP units** producing heat when residual loads are low, and electricity when residual loads are high or used as thermal storage.	2.1.6,	F2, F4, F5, F8, F10, F11,	🔴
2.2.1	1. **Pan-European market design** to foster the integration of large scale RES, storage, demand response, EVs, etc. in coordination with network operation taking into account uncertainties of production and demand.	2.2.6,	F1, F2, F4, F7, F8, F9, F10,	🔴
2.2.2	2. Market design for TSOs with **cross-border coordination** that involve multiple DSOs and aggregators and multi-operation zones. Market design for cross-border ancillary services (including joint procurement of reserves, sharing of reserves, fast ramping services for frequency response, inertia response, reactive power, voltage control and power flow control)	2.2.5, 2.2.7, 2.2.18,	F1, F2, F4, F5, F8, F10, F11, F12,	🔴
2.2.3	3. Market rules and coordination mechanisms for provision of **ancillary services by aggregated storage and virtual power plants,** comprising RES, flexible thermal generation (small and micro-CHP), heat-pumps, EVs, etc.	2.2.1, 2.2.8, 2.2.12,	F1, F2, F3, F4, F5, F7, F8, F9, F10, F11, F12,	🔴
2.2.4	4. Market design and cost benefit analysis for the **provision of ancillary services between DSOs and TSOs** through coordinated communications, coordinated smart metering and platforms, and considering physical grid constraints.	2.2.10, 2.2.14, 2.2.15,	F1, F2, F3, F4, F5, F6, F8, F10, F11, F12,	🔴
2.2.5	5. Design of **local markets and their interaction to central markets.** Retail (peer-to-peer) markets for Local Energy Communities with power balancing and coordinated LV/MV technical grid control.	2.2.11, 2.2.17, 2.2.19, 2.2.20, 3.3.7,	F1, F4, F5, F6, F7, F8, F10,	🔴
2.2.6	6. Market design for **large-scale demand response, beyond electricity**. Market models expressing the price-sensitive nature of loads obtained by smart metering and metrology methods.	2.2.3, 2.2.4, 2.2.5,	F1, F2, F3, F4, F5, F6, F8, F10, F11, F12,	🔴
2.2.7	7. Market design for **storage owners and operators**, including of EV. Market design for thermal storage in electricity and heating markets	2.2.2, 2.2.13, 2.2.21,	F1, F2, F4, F5, F6, F7, F8, F10, F11, F12,	🟠
2.2.8	8. Market rules for the provision of **system services (balancing) by gas networks** in case of low (or negative) residual loads when producing and storing chemical energy.	2.2.16,	F1, F3, F5, F8, F10,	🔴
2.2.9	9. Market design for system services (balancing) by **water cycle management operators**.	2.2.9,	F2, F8, F10, F11,	🟠
3.1.1	1. **Data exchange protocols / interfaces for a well-functioning market** between all players. Protocols for stochastic model-based handling of market operations on different timescales. Common, standardised models for encrypted and authenticated market orders	3.1.1, 3.1.4, 3.1.5,	F1, F3, F4, F5, F6, F7, F8, F9, F10, F11,	🔴

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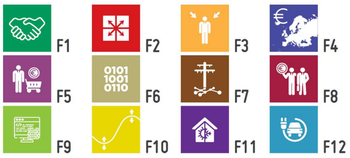
Full Task No	Tasks	Integrated Stakeholder tasks	Functiona-lities	24
3.1.2	2. **Standardized communication protocols and ICT infrastructure between devices and networks** and also between **devices and remote management platforms** to meet requirements of network operators, retailers and aggregators. Interoperability for devices and actors of the integrated energy system (e.g. prosumers, connected buildings, DSO, storage, RES, PV, EV) etc.	3.1.2, 3.1.3, 3.1.6, 3.1.8, 3.1.14, 3.1.15, 3.1.16,	F1, F2, F3, F5, F6, F7, F8, F9, F10, F11, F12,	● (red)
3.1.3	3. **Communication interfaces of smart substations**, especially on LV secondary substation level (interfaces for internal substation components and between substation with upper level and information systems, like EMS, SCADAS, legacy systems, etc.).	3.1.11, 3.1.13,	F2, F6, F7, F10,	● (red)
3.1.4	4. Universal device interfaces and protocols to enable **DSO and TSO information exchanges**. Data interfaces for utility business models and **decision-making support functions**.	3.1.7, 3.1.12,	F1, F6, F7, F8, F10,	● (red)
3.2.1	1. Communication infrastructures to support **demand aggregation and control**. M2M or AI2AI telecommunication solutions for services required by the energy grid (including AI algorithms for decision-making in device, MEC or cloud level).	3.2.1,	F1, F2, F3, F5, F6, F7, F10,	● (red)
3.2.2	2. ICT infrastructure for **monitoring and control of distributed generation**, e.g. PV systems, including standards and protocols.	3.2.2,	F2, F6, F7, F10,	● (orange)
3.2.3	3. Communication infrastructures for **smart meter data** for close to real-time monitoring in critical zones at critical moments (including non-GNSS (Global Navigation Satellite System) systems for time synchronisation and timestamping, consideration of latency, loss of packets, and jitter in end-to-end communications.)	3.2.3, 3.2.4,	F2, F5, F6, F7, F8,	● (red)
3.2.4	4. Optimise installation of ICT infrastructure, including costs, accuracy, redundancy, etc. for data collection and processing used for **conditional and risk-based maintenance**.	3.2.5,	F7, F9,	● (red)
3.3.1	1. **Big data management** from different sources: smart-meters, smart-sensors, social media, etc. for their use in planning tools, management tools, market platforms, etc. Data driven tools supported by data analytics, artificial intelligence, development of digital twins, etc.	3.3.1,	F1, F5, F6, F8, F10,	● (red)
3.3.2	2. Investigate the use of **IoT technologies** in TSO and DSO planning, asset management, operational and market activities.	3.3.2, 3.3.3,	F6, F7, F8,	● (red)
3.4.1	1. Methods and tools for **cyber security protection of grid infrastructures** to avoid injection of false data through physical installations, like primary and secondary substations, MV and LV lines, etc. Cybersecurity strategies for TSOs and DSOs	3.4.2, 3.4.3, 3.4.8,	F1, F6, F7, F8, F9,	● (red)
3.4.2	2. Data protection and **GDPR-compliant methodologies** for **management of distributed energy resources**, including decentralized storage	3.4.1, 3.4.4,	F3, F5, F6, F8, F10,	● (red)



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Full Task No	Tasks	Integrated Stakeholder tasks	Functiona-lities	24
3.4.3	3. Risk and vulnerabilities for **parallel use of legacy SCADA systems** (as a traditional means to provide remote supervisory and control)	3.4.5,	F1, F6, F7, F9,	🔴
3.4.4	4. Risks and vulnerabilities of using **public ICT and wireless infrastructures** for smart grid functionalities, e.g. connection with smart meters and energy boxes	3.4.6,	F3, F5, F6,	🔴
3.5.1	1. Digitalization of distribution and transmission networks. Creation of a **digital twin of interoperating grid and communication networks** to resolve performance problems and recovery from abnormal events.	3.5.2,	F1, F5, F6, F7, F8, F9,	🔴
3.5.2	2. Enhanced architecture design for **data exchange at different system voltage levels**, at different time frames with enhanced TSO/DSO communication interfaces.	3.5.3, 3.5.4,	F1, F2, F5, F6, F7, F8,	🔴
3.5.3	3. Application of **advanced ICT-based approaches** (IoT, edge computing, cloud computing, cyber-security, blockchain, etc) **for data storage** and computing on new (Hardware & Software) **architectural schemes**.	3.5.5, 3.5.6,	F1, F2, F6, F9,	🟠
4.1.1	1. Model of the energy system including all major energy carriers, encompassing the **whole energy chain** from prosumers, energy communities, e-transportation, distribution and transmission grids (LV, MV, HV), national and regional electrical and gas exchange, with clear boundary interaction.	4.1.1, 4.1.7,	F1, F2, F5, F7, F8, F9, F10, F11, F12,	🟠
4.1.2	2. Coordinated HV (including Ultra-HV) and MV distribution systems. Electricity transmission systems with storage infrastructure and using gas and heat infrastructures. **Resilience oriented sizing and spatial positioning of assets**, in order to withstand the impact of extreme weather and grid events.	4.1.5, 4.1.9,	F1, F2, F7, F9, F10, F11, F12,	🔴
4.1.3	3. Citizen energy communities, with energy management systems for **local multi-energy streams operation**, including electrical-storage, P2x generation and storage, and x2P (including CHP based on hydrogen and fuel-cells).	4.1.23,	F3, F5, F7,	🟠
4.1.4	4. **Multicarrier hybrid storage systems**, including their economic benefits in comparison to single storage units, their application to Power2Heat for balancing and storage, dynamic interaction between heat and electricity, their application at building level, dynamics of the coupled energy system considering the inertia of thermal loads (electricity-heating-buildings).	4.1.2,	F2, F5, F7, F8, F10, F11, F12,	🔴
4.1.5	5. **Optimally located, sized and coordinated electric energy storage at different voltage** levels in the power system (for fast and slow power response; for future ancillary supplementary services in the storage facility such as inertia support).	4.1.8,	F1, F7, F8, F9, F10,	🔴
4.1.6	6. **Optimally located, sized and coordinated** hydro, gas and chemical thermal and chemical **storage for seasonal needs**.	4.1.6,	F1, F2, F9, F10, F11, F12,	🔴

F1 F2 F3 F4
F5 F6 F7 F8
F9 F10 F11 F12

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4.1.7	7. **Web-of-Cells, decentralised, modular control architectures** for real-time voltage and frequency control (including AC, AC/DC hybrid and DC microgrids, local storage, smart transformers) utilizing flexibility from all energy carrier systems.	4.1.3, 4.1.4, 4.1.14, 4.1.15, 4.1.17, 4.1.18, 4.1.21, 4.4.3, 4.4.10, 6.4.6,	F1, F2, F3, F4, F5, F6, F7, F8, F9, F10, F11, F12,	🟠
4.1.8	8. **Integrated electricity AC and DC distribution network**s including large-scale electrification of heating, domestic and commercial heat pumps, EV charging stations, etc. DC and hybrid AC/DC networks connected to AC through FACDS (Flexible Alternating Current Distribution System), Smart transformers, MV/LV DC, etc. AC, AC/DC hybrid and DC microgrids and local storage for providing locally flexibility.	4.1.4, 4.1.14, 4.1.22,	F1, F2, F3, F5, F6, F8, F9, F10, F11, F12,	🔴
4.1.9	9. **HVDC meshed grids**. Optimization algorithms for HVDC grids design based on different optimization criteria (n-1 reliability criterion, loss of infeed risks, economic criteria, etc.) **and** p**arallel routing of DC and AC lines** on the same tower or parallel paths to utilise existing infrastructure paths.	4.1.13, 4.1.15,	F7, F9,	🔴
4.2.1	1. **Planning of integrated (coupled) energy systems** (heat and cooling, gas, electricity networks with an extension to water -waste and drinking- and public transport networks in urban areas). Planning tools to optimize the development of the electricity networks taking into account energy efficiency policies at the urban/city but also rural scale (interaction with other energy network, spatial planning).	4.2.4, 4.2.5,	F1, F2, F3, F7, F8, F9, F10, F11, F12,	🔴
4.2.2	2. Cost-effective, coordinated **investment planning in RES at EU level** (covers all time horizons and markets (from investment planning until real-time) and taking into account the effects of alternative market designs and the requirements for infrastructure development. Consider all flexibility means (demand response, energy storage, generation, transmission), including cross-carrier flexibility.	4.2.8,	F4, F5, F8, F9,	🔴
4.2.3	3. Electricity System **Planning for resilience,** including Grid designs, PV, Wind and Hydropower generation, storage and demand flexibilities against natural disasters (storms, floods, wildfires, etc) and human attacks, resilience oriented operational planning using stochastic approaches including multi-contingencies occurrence	4.2.13,	F10,	🟠
4.2.4	4. **DER solutions to handle network constraints in planning**. HV, MV and LV network reinforcements and LV, MV grid expansion planning considering the flexibility offered by controlling RES, demand, energy storage, power electronics, etc. (includes the use of data coming from the field (smart meters, monitoring systems at all levels, fault detection, etc.))	4.2.7, 4.2.9,	F1, F7, F9, F10, F11,	🔴
4.2.5	5. **Probabilistic planning taking into account the DER stochasticity,** i.e. RES, demand response, storage, self-consumption, and their uncertainty including for heating and cooling and the demand for mobility	4.2.3, 4.2.12,	F2, F4, F5, F7, F8, F9, F10, F11, F12,	🟠
4.2.6	6. Distribution System planning and asset management to cater for the integration of **massive integration of EVs** with fast, very fast, and inductive recharge technologies. (short-, medium- and long-term scenarios for the implementation of the adequate charging infrastructures, incl. battery swapping infrastructures	4.2.1,	F7, F8, F9, F10, F11, F12,	🟠
4.2.7	7. Planning of **LV and MV DC industrial and residential grids**. Added value of DC grids in integrating DER, incl. lower costs of BoS (Balance of System). Taking care for safety, especially in homes.	4.2.2, 4.2.10,	F5, F6, F7, F9, F10, F11, F12,	🔴
4.3.1	1. Development of ageing and failure models for **condition (risk) in planning LV/MV based maintenance,** considering maintenance cycling profiles (including extreme events), different time scales (from operation to planning) both for power system components (lines, substations, transformers, switches, breakers, etc.), ICT infrastructures (sensors, communication infrastructures) and smart meters.	4.3.5, 4.3.10, 2.1.4,	F4, F5, F6, F7, F8, F9,	🔴

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4.3.2	2. Development of models for **State of Health (SoH) estimates of transmission system components** conditions, e.g. SoH related to components' wear, oil level in transformer oil pits, SF6 level in switchgear and probabilities of failure. Investigation of parameters which impact the lifespan of HV transmission system components.	4.3.6, 4.3.7, 4.3.8, 4.3.11, 4.3.17,	F6, F7, F9,	🔴
4.3.3	3. **Model-based detection of component failures** with sensors, conditions monitoring; robotics for hostile environments in HV systems; live maintenance (drones). Improved maintenance of HV-system components related to environmental (e.g., tree growth rate, wind) and operational (e.g., hazard rate) effects on assets' lifetime (Holistic approaches).	4.3.7, 4.3.8, 4.3.11,	F6, F7,	🔴
4.3.4	**4. Remote LV/MV maintenance operation**s by digital communications and monitoring equipment	4.3.12,	F6, F7,	🔴
4.3.5	5. **HV and MV-asset management considering resiliency** against rare, severe-impact events due to natural catastrophes, terrorism, cyber-attacks using standardisation for diagnostic methodologies (for validating measuring chain, for safety of [live] operation).	4.3.9,	F6, F7,	🔴
4.3.6	6. **Training of maintenance operators** for their adaptation to digital environments (i.e. human-machine interfaces) and new robotic solutions. Optimise maintenance-related costs (accuracy, redundancy, etc.) of the ICT infrastructure for collecting and processing data (both for on-line monitoring of components and data storage)	4.3.14,	F7,	🟠
4.3.7	7. **Optimized lifespan of storage systems** and the failure modes, including stochastic cycling profiles, CAPEX, OPEX, efficiency.	4.3.1,	F7, F8, F9, F10,	🔴
4.3.8	8. Smart sensors and online monitoring and diagnostic systems for the **optimal maintenance of hydropower and pumped-storage units.**	4.3.13, 4.3.15,	F6, F10,	🟠
4.3.9	9. **Improved lifetime of thermal generation** with fast cycling ability and fuel flexibility.	4.3.3,	F6, F7, F9, F10,	🟠
4.4.1	1. Grid stability **support by DER** (distributed generation, storage and flexible demand) and by **microgrids and nanogrids** connected at the distribution networks to the stability and control of the bulk transmission network.	4.4.4,	F1, F5, F7, F10, F11, F12,	🔴
4.4.2	2. Control concepts for providing **synthetic inertia from power electronic converters** and additional damping of oscillations, for instance by conventional rotating machine concepts like the VFT (Variable Frequency Transformer)	4.4.5,	F5, F7, F10,	🟠
4.4.3	3. Stability and control of AC, DC and Hybrid **Microgrids in islanded mode of operation**.	4.4.6,	F1, F3, F7, F10,	🟠

Full Task No	Tasks	Integrated Stakeholder tasks	Functiona-lities	24
4.4.4	4. Models and tools for **converter driven stability** including fast interaction (dynamic interactions of the control systems of power electronic-based systems, e.g. DGs, HVDC, and FACTS with fast-response components of the power system, such as the transmission network, or other power electronic-based devices) and slow interaction (dynamic interactions with slow-response components, such as the electromechanical dynamics of synchronous generators phenomena	4.4.8, 4.4.9,	F7, F9, F10,	Red circle
4.4.5	5. Models and techniques (incl. artificial analysis) for rotor-angle, voltage and frequency **stability of large scale transmission systems with high penetration of Variable RES**.	4.4.2,	F6, F7, F9, F10,	Orange circle
4.4.6	6. Development and validation of **equivalent models of aggregated network and system components** consisting of multiple technologies and potential energy carriers in different environments for energy system stability.	4.4.1,	F2, F7, F8, F9, F10, F11,	Orange circle
4.4.7	7. Methods and tools to analyse **large-scale inter-area oscillations**. Dynamic stability in grids with multiple control systems	4.4.7,	F7, F9,	Red circle
5.1.1	1. **Optimal utilization of DSR** (Demand Side Response) **by TSOs and DSOs** and their coordination, respecting demand requirements, and required data.	5.1.1,	F1, F2, F6, F8, F10, F11, F12,	Orange circle
5.1.2	2. **Direct load control** in close collaboration with telecom operators	5.1.2,	F2, F3, F4, F5, F6, F10, F11, F12,	Orange circle
5.1.3	3. Incorporation of **Active Demand in DSO planning and operation**, to serve the needs of the connected end user and aggregators and to defer grid investments. Prediction of the amount of shifted energy or modified consumption in Distribution Networks considering data availability and information exchange models.	5.1.3, 5.1.4,	F1, F2, F5, F6, F8, F10, F11, F12,	Red circle
5.1.4	4. Models for demand flexibility provided by integrated **energy-intensive industries** (e.g. steel production) and **bulk energy storage** (P2G, CAES, LAES, etc.).	5.1.5,	F1, F2, F9, F10, F11,	Red circle
5.2.1	1. **Contribution of WTs (Windturbines) and PVs to system flexibility**. Development of efficient controls for wind turbines and PV MPPT (Maximum Power Point Tracking) to take into account flexibility, reserve sharing, etc.	5.2.11,	F9, F10,	Red circle
5.2.2	2. Increase **operational flexibility of hydropower and pumped storage plants**, while reducing the negative effects on highly reduced lifetime and security risks from sudden outage.	5.2.13,	F9, F10,	Orange circle
5.2.3	3. Increase the **flexibility of thermal generation**, i.e. their speed of ramping up and down, start-up/shut down capabilities and minimum loads. Increase efficiency and lower GHG and CO2-emissions without compromising ability for waste heat recovery (ORC, etc).	5.2.1, 5.2.7, 5.2.15,	F2, F7, F8, F9, F10, F11,	Red circle

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5.2.4	4. Increase **fuel flexibility of thermal power plants** for using (mixing and switching) different sources of CO2-neutral fuels (hydrogen, biomass and biofuels).	5.2.2,	F2, F7, F10, F11, F12,	🔴
5.2.5	5. Develop and test solutions for integrated **flexible small and medium scale thermal generation** of electricity, heating and cooling, storage, develop impact studies and demonstration (including environmental, user and societal and economic impacts).	5.2.2, 5.2.3, 5.2.5,	F2, F6, F7, F8, F10, F11, F12,	🔴
5.2.6	6. Development of highly efficient, integrated **cogeneration units** of varying size with **decoupled use of heat & power**, powered by hydrogen, biomass and biofuels.	5.2.4, 5.2.9, 5.2.12,	F1, F2, F7, F10, F11,	🔴
5.2.7	7. Develop **European hydro energy system model** based on hydro power data set. Develop European wide reservoir and river inflow data set based on up to date climate simulations.	5.2.10, 5.2.14,	F7, F9, F10,	🟠
5.3.1	1. Studies for **storage flexibilities in operation of electrical grids** (including Microgrids). Storage sizing and siting (also hybrid technologies) depending on applications and their characteristics (CAPEX, OPEX, cycling, lifetime, efficiency, interconnection with other energy carriers, environmental and social aspects (LCA))	5.3.2, 5.3.4, 5.3.9,	F5, F6, F7, F8, F9, F10, F11, F12,	🔴
5.3.2	2. Integration of **energy storage systems with conventional power generators**, such as cogeneration, hydropower, thermal plants to increase their flexibility and improve operation (incl. effectiveness and load hours of combined heat and power).	5.3.5,	F5, F6, F7, F10,	🔴
5.3.3	3. Flexibility potential from **aggregated heating (and cooling) storage at household / building / industrial level** to provide system services (balancing). Power-to-heat technologies, like heat pumps, heat boilers, etc.	5.3.7,	F2, F9, F10, F11, F12,	🔴
5.3.4	4. Large-scale **power-to-gas applications**: Dynamics of coupled, integrated energy systems when producing large quantities of methane (power-to-gas) to be injected into the gas system (pipelines and underground storages).	5.3.3, 5.3.8,	F2, F5, F8, F10, F11, F12,	🔴
5.3.5	5. **Stand-alone (islands) buildings, living quarters and small and medium sized businesses and industries**, supplied by renewable generation, sector-coupling and storage components (P2hydrogen, P2G, P2H, P2fuels (involving carbon capture), P2chemicals and vice versa; flex control of P2H conversions.	5.3.1,	F2, F3, F5, F6, F8, F9, F10, F11, F12,	🔴
5.4.1	1. Increasing **flexibility in transmission and distribution networks** by flexible, power electronics **grid technologies,** such as FACTS, PSTs and HVDC links, smart transformers (power electronics OLTCs), open soft points, FACDS, fault current limiters, etc.	5.4.1, 5.4.4, 5.4.5, 5.4.6,	F1, F2, F4, F5, F6, F7, F8, F9, F10,	🔴
5.4.2	2. Flexibilities provided by **distribution network reconfiguration**	5.4.1, 5.4.3,	F1, F2, F6, F7, F9, F10,	🔴

Red circle: Research (TRL 3-5)
Orange circle: Demonstr. (TRL 6-8)
Green circle: Deployment (TRL 9)

Full Task No	Tasks	Integrated Stakeholder tasks	Functiona-lities	24
5.4.3	3. Standardised **HVDC multi-terminal networks to coordinate power flows** among different regions and to connect off- and onshore Wind Power plants	5.4.2,	F1, F7, F9, F10,	Red circle
5.4.4	4. **Dynamic Line Rating** (DLR) solutions in capacity calculations of transmission and distribution grids .	5.4.7,	F6, F7, F8,	Red circle
5.5.1	1. Centralized and distributed algorithms for **efficient management of EV charging**, supporting business-to-customers and business-to-business relationships and ensuring easy and secure payments for customers (incl. roaming services).	5.5.1,	F2, F5, F7, F8, F10, F11, F12,	Red circle
5.5.2	2. Energy management in **transport electricity networks** (railway, metro, tramway, trolleybus, etc) to provide ancillary services to DSOs via storage facilities in the substations of the PCC (point of common coupling)	5.5.2,	F1, F2, F5, F7, F10, F11, F12,	Red circle
5.5.3	3. Flexibility services offered by transport electrification, especially **Electric Vehicles with Grid to Vehicle G2V and Vehicle to Grid V2G** capabilities on distribution grid operation, especially for load flattening, system balancing and voltage support.	5.5.3,	F2, F5, F7, F10, F11, F12,	Red circle
6.1.1	1. **Steady State and Dynamic State Estimation of transmission systems** using **intelligent monitoring devices**, like PMUs, intelligent sensors and data processing. (Distributed observability of the transmission system)	6.1.3, 6.1.4, 6.1.6, 6.1.7, 6.1.9,	F1, F2, F4, F5, F6, F7, F9, F10, F11, F12,	Red circle
6.1.2	2. Increased **Observability and State Estimation of distribution systems** (MV and LV) using smart meter consumer data. Advanced forecasting and data flow between DSOs and TSOs	6.1.1, 6.1.5, 6.1.8,	F1, F3, F5, F6, F7, F9, F10, F11, F12,	Red circle
6.1.3	3. **Real-time observability of RES** (algorithms and tools) and **improved forecasts** for operational planning purposes	6.1.2,	F9, F10, F11, F12,	Orange circle
6.2.1	1. Optimal **Load Frequency Control** considering requirements for telecommunication infrastructures, latencies and reliabilities	6.2.1,	F6, F7, F9, F10,	Orange circle
6.2.2	2. Contribution of **RES to primary voltage and frequency control** of power grids with emphasis on weak grids (including islands). Provision of primary reserves by kinetic energy of WT rotors, synthetic inertia by PE interfaced DER, PE based reactive power control, etc.	6.2.3, 6.2.4, 6.2.5,	F5, F7, F10,	Orange circle
6.2.3	3. **Primary voltage and frequency control of distribution grids** (interconnected or islanded) **with very low or no inertia** by Power Electronics interfaced DER, local storage and load, VPPs, etc.	6.2.2, 6.2.5,	F7, F9, F10, F11, F12,	Red circle

Full Task No	Tasks	Integrated Stakeholder tasks	Functiona-lities	24
6.3.1	1. Advanced **RES forecasting** considering weather forecasts, local ad-hoc models, historical data and on-line measurements.	6.3.2, 6.3.5,	F5, F6, F7, F9, F10, F11,	🔴
6.3.2	2. **Hydropower forecasting** based on weather, precipitation models and live sensors.	6.3.1,	F1, F9, F10,	🟠
6.3.3	3. Solving **location-based grid constraints** with the use of short-term forecasting of generation and load and exploiting customer behaviour and flexible loads, including EV charging.	6.3.2, 6.3.3, 6.3.8,	F3, F6, F7, F9, F10, F11, F12,	🟠
6.3.4	4. **Optimal scheduling** of generation units (unit commitment, economic dispatch), reserve allocation and optimal power flow **in highly uncertain conditions.**	6.3.2, 6.3.4,	F4, F6, F7, F9, F10,	🟠
6.3.5	5. Optimal **distribution network configuration** taking into account increased monitoring capabilities at distribution level, automatic LV and MV System Topology identification and day-ahead forecasting.	6.3.9,	F7, F9,	🟠
6.3.6	6. Massive use of **control technologies in secondary substations** and the resulting coordination needs for system operators.	6.3.10,	F7, F10,	🔴
6.4.1	1. Protection of **distribution networks with low fault currents** due to high penetration of PE interfaced DER	6.4.13,	F7, F9,	🔴
6.4.2	2. **DC grid protection, protection relays and breakers,** multi-vendor solution with the consideration of interoperability, standardization	4.1.13,	F7, F9,	🔴
6.4.3	3. Distribution network operational measures, like **topology optimisation** and DER operational planning for **increasing network resilience** against natural disasters, terrorism and cyber-attacks.	6.4.2, 6.4.9, 6.4.14, 6.4.16,	F3, F6, F7, F9, F10, F11, F12,	🔴
6.4.4	4. **Bottom up restoration** by DER support and storage including intentional islanding techniques via Microgrids and Web-of Cells approaches. Synchronization of DER and storage reconnection.	6.4.4, 6.4.6, 6.4.7, 6.4.11, 6.4.15,	F1, F2, F4, F5, F6, F7, F8, F9, F10, F11, F12,	🟠
6.4.5	5. **Self-healing techniques** at distribution level by automatic fault clearing procedures in automatic power system restoration	6.4.17,	F7,	🟠

24: TRL-Maturity Year 2024

Red circle: Research (TRL 3-5)
Orange circle: Demonstr. (TRL 6-8)
Green circle: Deployment (TRL 9)

Full Task No	Tasks	Integrated Stakeholder tasks	Functiona-lities	24
6.4.6	6. Efficient **Load Shedding techniques** and tools considering reactive power and voltage control	6.4.10,	F1, F7, F9, F11,	🔴
6.4.7	7. **Security support by various multi-energy carriers** in the distribution electricity network (e.g. electric pumps in the district heating and cooling networks, or in the drinking and wastewater networks, as well as electric compressors and control equipment in the gas network).	6.4.1,	F1, F2, F6, F9, F10, F11, F12,	🟠
6.4.8	8. **Pan-EU or multi-regional system restoration** based on coordination of tie lines and/or black start units, whilst considering system condition, system constraints, available resources and regulatory rules. Minimize negative impacts of switching actions from one Transmission System to the neighbouring ones.	6.4.3, 6.4.8, 6.4.12,	F1, F4, F5, F6, F7, F8, F9, F10,	🔴
6.5.1	1. **Wide Area Monitoring and Control Architecture for Transmission Systems**: High-performance and high-speed communication infrastructure combined with sensing technologies, automation and control methods, also for critical situations.	6.5.8, 6.5.13,	F1, F6, F7,	🔴
6.5.2	2. **Energy Management platforms for TSOs** (with the associated monitoring and control systems) able to **interact with local markets** and with embedded functionalities such as self-healing capabilities for fault management.	6.5.11,	F1, F5, F6, F7, F8, F10,	🔴
6.5.3	3. **Energy Management Platforms for DSOs** allowing **active participation of customers in energy market** and in the grid operation optimization, **interoperability** with other actors (retailers, aggregators, TSOs) for grid status and data and smart metering data processing. Advanced functionalities for forecasting, protection and optimization in preventive and corrective way.	6.5.2, 6.5.5, 6.5.6,	F1, F2, F5, F6, F7, F8, F10, F11, F12,	🔴
6.5.4	4. **Control center architectures for distributed network control** (e.g. Web-of-Cells and Microgrids) considering new sensors (e.g. fault detectors, voltage and current sensors in generation, storage, buildings, EVs, industry, etc) and also MV levels with limited bandwidths.	6.5.1, 6.5.9, 6.5.18,	F1, F2, F5, F7, F8, F9, F10, F11, F12,	🟠
6.5.5	5. Anti-islanding protection, control of **intentional islanding**. Technical, economic and regulatory dimensions of interaction with local DER for islanding.	6.5.10, 6.5.14,	F5, F7, F8, F9, F10,	🔴
6.5.6	6. Advanced **Training simulators for DSOs and TSOs** (e.g. **using Digital Twins**) in order to adapt to new Network Energy Management platforms (including multi-energy carrier systems).	6.5.3, 6.5.17,	F2, F3, F5, F6, F7, F8, F9, F10, F12,	🟠
6.5.7	7. **Advanced MMI (Man-Machine-Interface)** for Energy Management System control rooms at all voltage levels, provision of suitable indicators for resilience / vulnerability and other criteria to help network operators to make decisions for preventive and corrective actions.	6.5.4, 6.5.5, 6.5.12,	F1, F2, F5, F6, F7, F9, F10, F11, F12,	🔴

F1 F2 F3 F4
F5 F6 F7 F8
F9 F10 F11 F12

24: TRL-Maturity Year 2024

Red circle: Research (TRL 3-5)
Orange circle: Demonstr. (TRL 6-8)
Green circle: Deployment (TRL 9)

The initial 261 "Stakeholder tasks" defined by the ETIP SNET Stakeholders and used to build the above 120 tasks of the ETIP SNET R&I Implementation Plan 2021-2024, are provided in the next pages.

Stakeholder Task No	STAKEHOLDER Tasks (January 2020) - ETIP SNET R&I Roadmap 2020-2030
1.1.1	Transparency and public engagement related to the permit process for construction and maintenance of overhead transmission lines, underground cable and RES generation/storage facilities (hydro, wind, etc.), with the goal of improving public acceptance
1.1.2	End-user (customer) in the center: Sociological study; training and information programs for higher consumer awareness and their understanding of new electricity/energy systems; Knowing the opinion of the end-user about been the center of the system, about having an active participation in the grid operation; large-scale participation on AD schemes; mandatory cutbacks during peaks to guarantee reliability and stability
1.1.3	Increase communication campaigns, develop social impact studies and increase the involvement of citizen energy communities in building energy communities, of local and territorial bodies, grid operators and energy market players in the early stage of planning of the infrastructure, including increased resilience and sustainability
1.1.4	Human and animal exposure to EMF and 5G
1.1.5	Reduced effects of hydropower plants on the environment (e.g. hydropeaking effects, better sediment management, fish migration and fish protection, water quality, etc.) while flexibility of generation is increased
1.1.6	Improving public acceptance for construction and maintenance of overhead lines and Ultra-HV/HV/MV substations; e.g. “Transmission line tower and stations designs with less visual impact and audible noise”
1.1.7	Reduced environmental impact of partial undergrounding solutions (HV cables) and new technologies (FACTS, etc.)
1.1.8	Minimized birds’ collision with HV infrastructures and nurturing bird nests, collision with windmills
1.1.9	Transparency and Communication campaigns to increase public awareness of the need for large investments in ENERGY infrastructure to achieve decarbonization objectives. (e.g.: permit process for construction of hydro power and hydro reservoirs for flexibility purposes or for construction, repowering and maintenance of Wind power parks, deployment of the smart grid infrastructure and its communication tools, etc.)

Stakeholder Task No	STAKEHOLDER Tasks (January 2020) - ETIP SNET R&I Roadmap 2020-2030
1.1.10	Describe the state-of-the-art Social Science and Humanities (SSH) research and develop science-policy interface tools in the areas of Hydropower, Wind, Storage, Smart distribution grid …
1.2.1	Hardware and software solutions for AMI to measure electricity consumption, generation and send time-of use, dynamic tariffs when needed to the final prosumer
1.2.2	Community driven network upgrade by putting people (active prosumers, includes local and territorial bodies) before technology and data (provided post-consumption or in real-time)
1.2.3	Customers/Users participating in the retail market (Market rules (and the associated regulatory framework) to help customer participate in retail markets (energy efficiency offers) in a transparent and non-discriminatory way, with a special attention to data privacy)
1.2.4	Recommendations for the participation of prosumers in electricity markets (including the studies and demonstrations of local- and virtual energy markets; including public access to information from expert studies with outputs aimed for the public; possibility to consult outputs in the local information centers).
1.2.5	End-user impact evaluation and validation: Quantification of the impacts of AD response market mechanisms with market simulations at distribution level, including the coupling with market simulations at transmission level for the provision of system services by aggregators to TSOs, incl. market simulators long-term, day-ahead, intraday and real time markets
1.2.6	Complete behavioural motivations of the customers incl. for energy efficiency measures by considering the full environment, i.e. ergonomics (ICT environment), market (price signals), and behaviour (rebound effects and integration of energy services with non-energy benefits such as comfort and wealth, security)
1.2.7	Flexibilization of industry (as prosumer) behaviour in order to contribute with flexible integrated energy systems
1.2.8	Direct Messaging Channels at the supplier and distribution level to support consumer's needs

Stakeholder Task No	STAKEHOLDER Tasks (January 2020) - ETIP SNET R&I Roadmap 2020-2030
1.2.9	Taking advantage of client analytics for enhanced and proactive contact to increase consumer satisfaction with the service.
1.3.1	Develop and test devices enabling visualization and control (via protocols and standardization) of prosumers' electricity consumption/generation (for instance in-home displays with control functionalities) using low-cost and end-user friendly technologies (wireless technologies, PLC, smart phones, etc.)
1.3.2	Enable in-home ICT technologies empowering the consumer to act in a user-friendly environment (hardware and software solutions for connections with smart appliances, for measurement and control devices such as smart plugs and voltage clamps, for visualization such as in-home displays, web portals and smartphone apps; protocols and standardization)
1.3.3	Blockchain technology for peer to peer user communication and information exchange (including public value).
2.1.1	Business models for all stakeholders (especially retailers and aggregators, ESCOs and energy cooperatives) promoting energy efficiency at the end-user level (in relation with AD response), including innovation in Energy Performance Contracts.
2.1.2	Business models and market mechanisms for ancillary services provided by prosumers (incl. EV and other units and bidirectional storage)
2.1.3	Business models for storage in dedicated electricity networks for transportation (e.g. tramways, trains, busses)
2.1.4	Business models for actors in LV/MV systems (DSO, aggregator, retailer, data analysis service providers, consumers, prosumers, etc.) providing new energy services thanks to the availability of large-scale data bases and advanced data-mining techniques
2.1.5	Business models for actors using case-based legal, contractual and regulatory aspects of aggregated ancillary services provided by distributed generation, storages and / or loads.

Stakeholder Task No	STAKEHOLDER Tasks (January 2020) - ETIP SNET R&I Roadmap 2020-2030
2.1.6	Business case for producing heat when residual loads are low with e.g. large-scale heat pumps (green electricity) or individual electrical boiler (green electricity); electricity (gas-fired or biomass fired CHP units) when residual loads are high; using thermal loads as electrical boiler as storage for surplus electricity generation
2.1.7	Business models and market mechanisms for ancillary services provided by EVs in different EV charging infrastructures and cost benefit analysis (CBA). Cost benefit analysis (CBA) of EV charging infrastructures.
2.2.1	Recommendations on market rules and mechanisms for provision of ancillary services.
2.2.2	Market design (and the associated regulatory framework) for thermal storage for participation in electricity and heating markets
2.2.3	Very large-scale demand response beyond electricity that involves multiple DSOs and aggregators, multi-operation zones, several thousands of customers and possibly TSOs with cross-border coordination (including stringent constraints and under emergency situations)
2.2.4	Enable aggregators to provide AD-based system services from DSO to TSO through coordinated communications between TSOs and DSOs (Large-scale real implementation and its cost benefit analysis)
2.2.5	Cooperation strategies for connected DSOs to support cross-border AD-based service provisions, considering the difference between DSOs in their technical ability and policy (incl. commercial and regulatory barriers; compensation mechanisms for mandatory partial consumption cutbacks related to the promotion of grid reliability and stability in peak consumption periods.)
2.2.6	Pan-European market design to foster the integration of the emerging technologies (RES, storage, DR, EVs) (geographical and temporal extensions into intraday) and the coordination with network operation incl. stochastics approaches
2.2.7	Cross-border market design for ancillary services (including joint procurement of reserves, sharing of reserves, fast ramping services, frequency response, inertia response, reactive power, and voltage control)

Stakeholder Task No	STAKEHOLDER Tasks (January 2020) - ETIP SNET R&I Roadmap 2020-2030
2.2.8	Viability and options of ancillary service provision by aggregated loads and other sources of flexibility (incl. cross-border, interaction with other AS markets; market design; aggregation strategies). Advanced simulation environment to be developed
2.2.9	System services (balancing) brought by water cycle management operators and network operators in case of low (or negative) residual loads
2.2.10	Market design with associated flexible coordination between TSO and DSO considering physical grid constraints, ancillary services and uncertainties, considering the state of art of the ongoing projects (Coordinet, Interflex, etc.).
2.2.11	Retail (peer-to-peer) markets with power balancing and coordinated LV/MV technical grid control
2.2.12	Market rules and mechanisms for provision of ancillary services by RES, flexible (and in the future CO2-neutral) thermal generation, by virtual power plants such as from small and micro-CHP, complemented by heat-pumps (recommendations, coordination with technical aspects, implementation, operation, demonstration, etc.). Grid cases, involving also AMM and AMI, in which the technical grid control and the market-based power balancing are relevant (aggregation, VPP, microgrids, prosumer communities, secondary substation overload management, grid section instability, grid section planning, etc.)
2.2.13	Storage-Grid operator coordination mechanism / platform / interface including aggregation in order to better control the power system and maximise social welfare.
2.2.14	AD-based system services related to the role of substations from aggregators for TSOs through DSOs (incl. standard definition of the services and data to be exchanged)
2.2.15	Market models considering the price-sensitive nature of loads and vRES/vDER and their resulting flexibility, their aggregation potential and the irrational behaviour of market participants (including limiting the rated power during a specific period of time)
2.2.16	System services (balancing) brought by gas network operators in case of low (or negative) residual loads when producing and storing chemical energy

Stakeholder Task No	STAKEHOLDER Tasks (January 2020) - ETIP SNET R&I Roadmap 2020-2030
2.2.17	Smart metering of physical quantities related to ancillary services, aggregation and disaggregation of measured services for an aggregator activity, based on smart meters and metrology methods
2.2.18	Provide demonstrations of power flow control devices and storage that offer increased flexibility with respect to energy flow across multiple transmission zones and borders
2.2.19	Platforms including innovative control strategies to better manage DER (including storage and DR) allowing aggregation and taking into consideration the technical operation of the grid by DSOs.
2.2.20	Incorporating RES into operation processes via aggregation schemes, utilizing forecasts and benefiting from controllability of RES (for coordinated reactive power/voltage control, congestion management, etc.).
2.2.21	Ancillary services provided by EVs
2.3.1	Regulatory bodies: regulatory framework to promote the use of DR (Demand Response) based on the cost-benefit analysis
2.3.2	Regulatory Framework including the remuneration schemes for new market stakeholders aggregators, providing related to added value of DER (distributed generation, storage and DR) in the provision of grid services (balancing, reserves, ancillary services, etc.) and flexibility at the distribution level and the impact in the transmission level
2.3.3	Amended regulatory frameworks for pan-European Internal Market for Electricity needs (definition of common rules and regulation to push the Internal EU Market, validated by simulations); account for the behaviour of the different actors involved each with his own interest (Procurement and regulatory framework for localized and non-localized ancillary services).
2.3.4	Regulatory arrangements to allow temporary use of DER for grid management purposes by DSO and TSO given regulatory unbundling rules

Stakeholder Task No	STAKEHOLDER Tasks (January 2020) - ETIP SNET R&I Roadmap 2020-2030
2.3.5	Regulatory issues regarding market design, tariff schemes, incentives and network regulation for EV and other DER integration (incl. regulatory barriers, market design principles, grid-system services)
2.3.6	National regulatory schemes in order to foster cross-border coordination efforts
2.3.7	New regulatory options for Citizen Energy Communities
3.1.1	Protocols (expert systems) for stochastic model-based handling of market operations on different timescales for improved reliability
3.1.2	Universal virtual and open device interface and protocols to enable DSO and TSO information exchanges with DER (mainly for third party owned PV and storage) from different manufacturers and using different technologies. The activity covers both regional and European (cross-border) scopes.
3.1.3	Low-cost, but cyber secure Plug-and-Play and open source/ open protocol solutions (easy to put in service production and test of devices; inbuilt energy supply solutions) equipment and telecommunications including for energy needs (health, weather, heating, cooling, mobility)
3.1.4	Standardization in data exchange protocols based on T3.01 / interfaces between all equipment and players that are required for a well-functioning market and a safe grid (switching, metering at least)
3.1.5	Common, standardised models for encrypted and authenticated market orders which could be common to all smart grid stakeholders.
3.1.6	Interoperability issues for all devices and actors of the integrated energy system (e.g. prosumers, connected buildings, DSO, storage, RES, PV, EV) etc.

Stakeholder Task No	STAKEHOLDER Tasks (January 2020) - ETIP SNET R&I Roadmap 2020-2030
3.1.7	Protocols for data transfer, utility business models and decision-making support, interfaces between Big Data management and enhanced planning and operational tools (ENTSOE + DSOs + ICT providers + MNOs (Mobile network operators) (Planning and operational tools (development) considering bi-directional data transfer and connectivity issues)
3.1.8	Standardized communication protocols and ICT infrastructure between devices and the networks, but also between devices and remote management platforms to meet requirements from network operators, retailers and aggregators (in particular cybersecurity)
3.1.9	Create recommendations regarding protocols to be promoted for specific communications purposes within the energy communication network system, e.g., the IEC 61850 standard series, IEC 61970 (CIM) standard series, IEC 61968 (CIM) standard series, IEC 62325 (CIM), IEC 61400-25 standard series, ISO/IEC 9594 standard series, ITU-T X500 standard series
3.1.10	Application guidelines and recommended practices for implementation of protocols with open Source / open protocol solutions
3.1.11	Large scale deployment of smart substations under the IEC standards (61850 and 61970/61968 CIM) using wired or wireless communication.
3.1.12	Standardization of certain functionalities of the Geographic Information System (GIS) used by the different system operators to share information related to flexibility, energy exchanges, connection data.
3.1.13	Communication interfaces on LV secondary substation level (Telecommunication and control architectures (interfaces for Secondary Substation (SS), consumers, DERs, etc); Communication interfaces: internal to the SS components; between SS and other grid systems both up and down stream; between the SS and other upper level and information systems (EMS, SCADAS, legacy systems, etc.). Authenticating and authorizing users (maintenance personnel for instance) to IEDs (Intelligent Electronic Devices) in substations, implementing cyber security best practices (zoning, network separation, access control, whitelisting, malware detection, backup plans, disaster recovery, redundancy, regular security patches, logging and monitoring, etc.)
3.1.14	Efficient processes related to the exchange of data and information between the MV and LV levels regarding coordinated reactive power and load management (load control, load shedding, underfrequency shedding; including support for AI based decision-making in device (highly distributed), MEC / router (medium distributed), and service cloud (centralised) levels.)
3.1.15	Interoperability standards for DSO: List of standards considered and their coverage for the complete value chain; Common test standards for AD (Aggregate Demand).

Stakeholder Task No	STAKEHOLDER Tasks (January 2020) - ETIP SNET R&I Roadmap 2020-2030
3.1.16	Standardisation and interoperability between TSO / DSO on physical and cyber security protection
3.2.1	Communication infrastructure (possibly distributed, meshed, resilient) to support the whole system allowing demand aggregation and control (cf. Upgrading of the network) and M2M or AI2AI telecommunications solutions adapted to the type of services required for the future energy grid (including AI algorithms for decision-making in device, MEC or cloud level, possibilities to develop open virtual interfaces to increase the availability and volume of new ancillary services; localisation as means for asset management and navigation services for maintenance personnel).
3.2.2	ICT infrastructure supporting PV integration, i.e. monitoring and control of distributed PV systems, including standards and protocols. And vice versa, PV systems to power the smart grid base stations e.g. in abnormal situations (Development of self-sustained (PV powered) base stations for grid communication)
3.2.3	Testing smart meters with capabilities to contribute to almost real-time monitoring in critical zones at critical moments (including non-GNSS (Global Navigation Satellite System) systems for time synchronisation and timestamping, including consideration of latency, loss of packets, and jitter in end-to-end communications.)
3.2.4	Use of the smart meters and the communication structure for AMM as an information channel for market-compatible load control, including pricing signals and bids. Especially barriers in rural areas with limited communication capabilities need to be assessed.
3.2.5	Development of open-source Software to optimise costs (accuracy, redundancy, etc.) of the ICT infrastructure collecting and processing data (both for the on-line monitoring of components and data storage) to feed the data mining algorithms for conditional and risk-based maintenance.
3.3.1	Manage big data from different sources: planning tools, management tools, market platforms, Smart-meters, social medias, etc. (infrastructures or tools) by data analytics, applications of artificial intelligence, Digital twin, etc.
3.3.2	IoT in TSO and DSO activities (Potential benefits, whitepaper, study on secure application of IoT technologies through the public internet, taking both benefits, risks and privacy into account)
3.3.3	Use of IoT in TSO and DSO planning, asset management and operational activities and interfaces to market activities

Stakeholder Task No	STAKEHOLDER Tasks (January 2020) - ETIP SNET R&I Roadmap 2020-2030
3.4.1	Recommendations on additional to GDPR implementation for the secure and privacy-compliant access of data of prosumers
3.4.2	Physical and cyber security protections to avoid fraudulent or destructive access or injection of fault data through physical installations (primary and secondary substations, MV and LV lines, etc. vs. people, AI M2M, robotic vehicles/drones, epidemics) to ICT systems
3.4.3	Improved protections measures for the HV, MV, LV grid infrastructures (cyber-attacks, terrorism, weather, migration, etc.)
3.4.4	Data protection and cyber security methodologies for automatic control of decentralized storage (inc. protection, reconfiguration, self-healing, optimization, coordination, connectivity and communications etc.)
3.4.5	Risk and vulnerabilities for parallel use of legacy SCADA systems (as a traditional means to provide remote supervisory and control) with IoT based system approaches
3.4.6	Risks and vulnerabilities by use of public ICT and wireless infrastructures for smart grid purposes (e.g. connection with the customers through smart meters and energy boxes (for example for demand-response signal or metering) (including assessment of pros and cons of public and private networks and network slicing to increase security, reliability, and more guaranteed throughput).
3.4.7	Restoration plans and redundant backup systems with sufficient power supply especially for ICT and software systems, in order to keep running the grid operation in case of natural catastrophes, terrorism and cyber-attacks (consider automation in restoration process)
3.4.8	Cybersecurity for TSOs and DSO's (Strategy, best practice guideline for TSO and DSO Substation and ICT system security design; dissemination plan for strategic initiative)
3.4.9	Failure modes of ICT (including sensors) including different kinds of sensors, intrusion prevention and detection systems, active and reactive security and support for quick recovery with AI solutions covering grid and communication aspects

Stakeholder Task No	STAKEHOLDER Tasks (January 2020) - ETIP SNET R&I Roadmap 2020-2030
3.4.10	Cybersecurity for the integrated energy system (mechanisms to counter attacks; platforms; privacy - from markets to household appliances)
3.5.1	Communication handbooks and open-source tools to increase the level of robustness of the future LV/MV grids and systems infrastructures, communication needs and their operation by smartness, by infrastructure, by storage, by RES, by stand-by-generation and storage, in order to face extreme events due to climate change (high temperatures, floods, etc.) and due to natural hazards (earthquakes, etc.; including environmental footprint and the social acceptance of new equipment and role of consumers).
3.5.2	ICT and digitalization of distribution (and transmission) networks. Creation of a digital twin of interoperating grid and communication networks to resolve performance problems and recovery from abnormal events.
3.5.3	Enhanced architecture design for data exchange at the different system voltage levels, in different time frames with enhanced TSO/DSO communication interfaces (includes feedback on the design of the architecture from the implemented system prototypes).
3.5.4	Application of advanced ICT-based approaches (IoT, edge computing, cloud computing, cyber-security, blockchain, ...) for both grid data storage and computing on new (Hardware & Software) architectural schemes; research concepts beyond LV remote monitoring and control architectures to automation architectures. Middleware layers (with multi-agent systems) as a possible alternative for the management of LV/MV networks hosting large share of renewables (including storage). Distributed online analytical data streaming and processing. Pre-integrated architectures and open source frameworks and tools
3.5.5	LV and MV Telecommunication and Control architectures including information models (e.g. 61850) and communication infrastructure with existing, expected, and desired factors to be integrated/aggregated and conformance to IEC 61850, IEC 61970, IEC 61968, IEC 62325, and CIM standards to support integration
3.5.6	Application of cyber physical systems concepts, methods and tools to energy systems, with a focus on use of pre-integrated architectures and open source frameworks and tools from other industrial sectors.
4.1.1	Open Source SW for a hierarchical model of the major energy carriers, starting from more independent and resilient prosumers, energy communities (through their own controlled microgrids and energy streams), urban e-transportation, levels of distribution grids (LV, MV, HV), national and regional electrical and gas exchange, with clear boundary interaction.
4.1.2	Multicarrier hybrid storage systems: economic benefit of designing and operating an hybrid storage system in comparison to a single storage unit with current market conditions (incl. Application to Power2Heat for balancing and storage; dynamic compensation between heat and electricity; apply to building level, investigate the inertia of thermal loads so as to better grasp the dynamics of the coupled energy system (electricity-heat-buildings).

Stakeholder Task No	STAKEHOLDER Tasks (January 2020) - ETIP SNET R&I Roadmap 2020-2030
4.1.3	Web-of-Cell: Innovative control architecture and solutions for real-time voltage and balancing (frequency) control in the 2030+ power system, utilizing flexibility from all energy carrier systems and building on ubiquitous sensing and dynamic/autonomous control functions based on web-of-cell architecture (WoC). It includes the development of control functions, the different roles of actors and the interaction with the market processes, new control room functionalities as well the required steps to transfer the WoC approach into the power system.
4.1.4	Develop modular electricity system infrastructures, both in term of size/capacity and in terms of voltage level. This will include AC, AC/DC hybrid and DC microgrids and local storage for mitigating locally most of the needed flexibility
4.1.5	Coordinate HV (including Ultra-HV) and MV Electricity transmission planning with storage infrastructure and gas and heat infrastructures.
4.1.6	Open-source Software (simulation) tool for energy supply security based on large-scale centralized seasonal energy storage (e.g. thermal or chemical) over weeks to months.
4.1.7	Impact assessment on technical and economic aspects, and sustainability aspects of the transition towards a new model for a European energy system (heat, transport, gas, electricity).
4.1.8	Optimally located, sized and coordinated electric energy storage at different voltage levels in the power system (for fast and slow power response; for future ancillary supplementary services in the storage facility such as inertia support).
4.1.9	Geospatial and grid-expedient sizing of assets (storage, conventional units, etc.) considering the availability of grid assets in order to withstand the impact of extreme weather and grid events.
4.1.10	Integrated design of the storage devices, e.g. joint design between battery manufacturers and power electronics providers (goal: optimise costs with the maximum coverage in terms of functionalities), applied to both consumer and utility scale battery system with Integrated PV+Storage systems; consider also 2nd life batteries (refurbishing, replacing, recycling).
4.1.11	Software tools to enable incentives for DSOs to determine where the connection of new generation units, loads and storage should be encouraged (signal to market players).

Stakeholder Task No	STAKEHOLDER Tasks (January 2020) - ETIP SNET R&I Roadmap 2020-2030
4.1.12	DC grid protection, protection relays and breakers, multi-vendor solution with the consideration of interoperability, development and implementation of DC protection testing methods and standardization
4.1.13	Influence of parallel routing of DC and AC lines in the same tower or parallel paths to utilise existing infrastructure paths in an optimal manner.
4.1.14	Open Source Software for Distribution network modelling and optimization tools for planning and asset management in the presence of large-scale electrification of heating, including domestic and commercial heat pumps.
4.1.15	Design of HVDC meshed grids with enhanced reliability. Optimization algorithms to design HVDC grids based on different optimization criteria (n-1 reliability criterion, loss of infeed risks, economic criteria, etc.).
4.1.16	Lower and higher frequency AC networks as an alternative to DC.
4.1.17	Develop protection schemes as well as remote control systems for two-way power flows (communication with power electronics of generation and storage) and network switches
4.1.18	Integrated voltage control and congestion management in distribution networks by means of smart equipment (Smart Transformers, smart operator systems, controllable loads)
4.1.19	Software tools for cost-benefit assessment of expansion options and for validating the impact on grid planning of coordinated design of architecture, power flow control devices and other expected technologies.
4.1.20	New actuators (e.g. switches) and new sensors (e.g. fault detectors, voltage and current sensors) for MV network

Stakeholder Task No	STAKEHOLDER Tasks (January 2020) - ETIP SNET R&I Roadmap 2020-2030
4.1.21	DC and hybrid AC/DC networks, connected to AC through FACDS (Flexible Alternating Current Distribution System), Smart transformers, or MV/LV DC, targeting high resilience, enabled by local storage devices.
4.1.22	Urban e-Mobility, including e-charging stations, as embryo for DC and hybrid AC/DC networks, with high resilience, enabled by local storage devices.
4.1.23	Resilient citizen energy communities, with energy management systems of their microgrids, local multi-energy streams operation, including electrical-storage, P2x generation and storage, and x2P (including CHP based on hydrogen and fuel-cells).
4.1.24	Pan-European study regarding the roof-top PV production potential, using modern technologies such as LIDAR and satellite imagery, to improve knowledge about self-sufficiency in smart cities and communities.
4.2.1	Open Source Software for Distribution network modelling and optimization tools for planning and asset management in the presence of massive integration of EVs (short-, medium- and long-term scenarios for the implementation of the adequate recharge infrastructures needed for the assessment; incl. EV charging and battery swapping infrastructures accounting their network integration (with fast, very fast, and inductive recharge technologies).
4.2.2	Added value of LV DC grids in integrating DER while taking due care for safety (incl. to lower costs of BoS (Balance of System)) and to better control power flows when coupling DER, storage and other DC devices: research is needed for safety, especially in homes).
4.2.3	Develop probabilistic planning methods that respect the variability of RES, demand response, storage, self-consumption, and their uncertainty including for heating and cooling and energy demand of mobility.
4.2.4	Analysis of the planning and operation (steady state analysis and dynamics) of the coupled energy systems (heat and cooling, gas, electricity networks with an extension to water -waste and drinking- and public transport networks in urban areas).
4.2.5	Planning tools to optimize the development of the electricity network taking into account energy efficiency policies at the urban/city but also rural scale (interaction with other energy network, spatial planning).

Stakeholder Task No	STAKEHOLDER Tasks (January 2020) - ETIP SNET R&I Roadmap 2020-2030
4.2.6	Investigate state-of-the-art planning methodologies and software, technology portfolios and different regulatory frameworks
4.2.7	Efficient LV/MV grid expansions in the context of smart monitoring and controls of RES and demand and the use of storage (includes using data coming from the field (smart meters, monitoring systems at all levels, fault detection, etc.) to improve the planning process and the associated tools, taking into account the potential flexibilities brought by grid extensions in specific areas. Handbook for efficient grid extension permitting processes and procedures.
4.2.8	Open-source SW/simulations for more cost-effective, coordinated investments in RES, assuring both system adequacy and system security, at EU level (covers all time horizons and markets (from investment planning until real-time) and taking into account the effects of alternative market designs and the potential for infrastructure development. Consider all flexibility means (demand response, energy storage, generation, transmission), including cross-carrier flexibility.
4.2.9	Open-source optimisation and simulation environments (1-hour intervals of the year) for alternatives to HV, MV and LV network reinforcements and new transmission and distribution lines/links e.g. by using energy storage, power electronics, etc. (starting from a grid-model).
4.2.10	LV and MV DC industry and public grids – balancing, micro-/nanogrids controllers, e-mobility and public transport mix.
4.2.11	Open Source Software for planning tools to provide a complete simulation environment allowing electromagnetic transient studies for power electronics and accounting for all components of LV networks (all components, but also power electronics (inverters), harmonic distortion).
4.2.12	Open Source Software for planning to optimize location, coordination, control and integration of technologies within the existing and future system architecture and operation.
4.2.13	Impact and related mitigation measures of different climate change effects on the energy system, in particular on PV, wind and on hydropower generation and storage capacity (discharge characteristics, flood events, …).
4.3.1	Optimized lifespan and costs/profitability of the storage systems and the failure modes, including stochastic cycling profiles, CAPEX, OPEX, efficiency.

Stakeholder Task No	STAKEHOLDER Tasks (January 2020) - ETIP SNET R&I Roadmap 2020-2030
4.3.2	Open-source LV/MV planning tools and related training considering ageing and failure models and condition based maintenance, accounting for conditional maintenance constraints (and flexibilities) (new cycling profiles (including extreme events) both for the power component (lines, substations, etc.) and the ICT infrastructure, by using, data mining techniques, probabilistic approaches, etc; risk-based maintenance to address different time scale (from operations to planning); Training of maintenance operators for their adaptation to the new digital environment (e. man-machine interfaces) and new robotic solutions. Optimise costs (accuracy, redundancy, etc.) of the ICT infrastructure collecting and processing data (both for the on-line monitoring of components and data storage) to feed the data mining algorithms for conditional and risk-based maintenance)
4.3.3	Improved lifetime, fast cycling ability, fuel flexibility of thermal generation with the goal of reliable operation.
4.3.4	Open-source LV/MV planning tools and related training considering ageing and failure models and condition based maintenance, accounting for conditional maintenance constraints (and flexibilities) (new cycling profiles (including extreme events) both for the power component (lines, substations, etc.) and the ICT infrastructure, by using, data mining techniques, probabilistic approaches, etc.
4.3.5	Open-Source Software for Risk-based maintenance to address different time scale from operations to planning.
4.3.6	Open-Source Software for the State of Health estimates and probabilities of failure as a flexibility option in particular, when operating the network close to its physical limits so as to optimize the time of maintenance and the impacts on operations; e.g. SoH related to components' wear, oil level in transformer oil pits, SF6 level in switchgear.
4.3.7	HV-system using AI methods for model-based detection of component failures with sensors, conditions monitoring; robotics for hostile environments; live maintenance (drones).
4.3.8	Increased maintenance sensitivities of HV-system components related to environmental (e.g., tree growth rate, wind) and operational (e.g., hazard rate) effects on assets' lifetime (Holistic approaches).
4.3.9	Scaling up of HV and MV-asset management: model rare, severe-impact events (Natural catastrophes, Terrorism, Cyber-attacks) thereby applying standardisation for diagnostic methodologies (for validating measuring chain, for safety of [live] operation).
4.3.10	Ageing and lifespans of MV/LV network component (e.g. transformers, switches, breakers, etc.): Prediction algorithms including the associated ICT infrastructure (sensors, communication infrastructures) and smart meters.

Stakeholder Task No	STAKEHOLDER Tasks (January 2020) - ETIP SNET R&I Roadmap 2020-2030
4.3.11	Parameters with impact on lifespan of HV transmission system components; Evaluated protocols for component conditions.
4.3.12	Remote LV/MV maintenance operations of communications and monitoring equipment by open-source tools (especially for the new digital environment).
4.3.13	Online monitoring and diagnostic systems which predict the optimal maintenance interval for hydropower and pumped-storage units with the aim of revenue optimization and lifetime extension.
4.3.14	Training of maintenance operators for their adaptation to the new digital environment (e.g. man-machine interfaces) and new robotic solutions.
4.3.15	New (smart) sensors and online monitoring and diagnostic systems which predict the optimal maintenance interval for hydropower and pumped-storage units with the aim of revenue optimization and lifetime extension.
4.3.16	Optimised handling of AC and DC power transmission on same tower.
4.3.17	Methods for Evaluation of protocols for transmission system component conditions.
4.3.18	Advanced management of existing assets: lifecycle estimation and failure mechanisms and models, advanced asset management techniques (based on risk approach, reliability etc.), diagnostics, monitoring, life extension, reliability and vulnerability evaluation, failure mechanisms and models, etc.
4.4.1	Validation studies of aggregated components consisting of multiple technologies and potential energy carriers in different environments and for energy system stability.

Stakeholder Task No	STAKEHOLDER Tasks (January 2020) - ETIP SNET R&I Roadmap 2020-2030
4.4.2	SW (expert systems) to assist in transient stability analyses of rotor-angle, voltage and frequency in transmission systems.
4.4.3	Web-Of-Cell: Analyse, monitor and control in real time the stability of power systems highly engaged by power electronics devices providing ancillary services.
4.4.4	Grid support capabilities and benefits provided by DER, storage and DR in the distribution networks and the links between the Distribution and Transmission Networks.
4.4.5	Develop new technology and control concepts for providing synthetic inertia from power electronic converters and additional damping of oscillations, for instance conventional rotating machine concepts like the VFT (Variable Frequency Transformer)
4.4.6	Micro- and Nanogrid power system stability support under major real life disturbances.
4.4.7	Software for removing large-scale intra-zone oscillations. Higher stability in grids with multiple control systems.
4.4.8	Stability of HVDC links and the interactions between HVDC converters, grid control systems, wind farms converters, synchronous generators and power system impedances.
4.4.9	Tools to study converter driven stability
4.4.10	Tools for MV power system stability analysis with a high penetration of power electronics.

Stakeholder Task No	STAKEHOLDER Tasks (January 2020) - ETIP SNET R&I Roadmap 2020-2030
5.1.1	Optimal TSO- and DSO-related DSR utilization by defined demand requirements and required data.
5.1.2	Develop and test solutions for direct load control (in close collaboration with telecom operators) via smart meters and/or the energy boxes installed by service providers.
5.1.3	Evaluation criteria, validation procedure and implementation guideline to assess the amount of shifted energy or modified consumption in AD schemes, considering different levels of data availability and information exchange models.
5.1.4	Incorporate Active Demand beyond electricity in DSO planning and operation, to serve the needs of different stakeholders (e.g. DSO, TSO, end user, aggregator) incl. rebound and deferral effects; provide reliable models to predict them so as to provide DSOs with methods to anticipate their impacts on network operations.
5.1.5	Simulation tools for potential of integrated energy-intensive industries (such as H2FUTURE project with steel production) and bulk energy storage (P2G, CAES, LAES, etc.).
5.2.1	Faster thermal generation ramping down and up as well as start-up/shut down: increase the rate at which a thermal generation unit can start/shut down and when running, increase or decrease its output (load following capability).
5.2.2	Increase thermal power plants flexibility for using CO2-neutral fuels (to be able to use different sources of fuels (mixing and switching); demonstrate integration of thermal power plant technologies with high electrical efficiency that can use hydrogen, biomass and biofuels). Consideration of specific aspects related to mini- and micro thermal power plants involved in the future distributed generation. Impact studies and demonstration (including environmental, user and societal and economic impacts).
5.2.3	Develop and test solutions for integrated flexible small and medium scale generation of electricity, heating and cooling.
5.2.4	Integrated cogeneration units, energy-grids-connected, highly efficient, dispatchable, flexible, varying size; decouple the use of heat & power, use hydrogen, biomass and biofuels and different storage technologies.

Stakeholder Task No	STAKEHOLDER Tasks (January 2020) - ETIP SNET R&I Roadmap 2020-2030
5.2.5	Quantified benefits of energy storage services associated to thermal power plants (value of hybrid technologies, mixing technologies able to perform a high number of cycles with other less CAPEX intensive technologies).
5.2.6	Assistance for optimal (flexibility) technology selection incorporating efficiency of the investment and system security criteria (Development of methodologies).
5.2.7	Improved lifetime, fast cycling ability, fuel flexibility of thermal generation with the goal of reliable operation.
5.2.8	Develop a seamless, integrated and knowledge-based system from components and system condition, resources to an optimized revenue generation from energy and flexibility markets. System-based models for the whole generation/storage units by the means of artificial intelligence, machine-based learning and digital twins of generation/storage units/plants
5.2.9	Optimise the connection, control and management of CHPs connected to district heating networks, including those coordinated as "virtual power plants", so as to provide flexibility.
5.2.10	Sufficiently detailed open source European hydro power model and data set for energy system modelling.
5.2.11	Wind turbine control and PV MPPT (Maximum Power Point Tracking) controls to take into account flexibility, reserve sharing, etc.
5.2.12	Decouple in thermal power plants the use of heat and power (e.g. via buffers, storage, power-to-heat, power-to-gas, power-to-fuel) and energy-intensive industries with CHP.
5.2.13	New technology, inventions and methods giving increased operational flexibility to hydropower and pumped storage plants, while reducing the negative effects of such harsh operation, such as highly reduced lifetime and security risks from sudden outage.

Stakeholder Task No	STAKEHOLDER Tasks (January 2020) - ETIP SNET R&I Roadmap 2020-2030
5.2.14	Open source European wide reservoir and river inflow data set based on up to date climate simulations.
5.2.15	Reduction of minimum load of thermal generation units (without reducing reliably operation), increasing performance (higher efficiency; lower GHG and CO2-emissions) without compromising ability to adapt to waste heat recovery (ORC, etc).
5.3.1	Studies and developments of flexible systems for stand-alone or grid-connected living quarters and small and medium sized businesses and industries based on renewable generation, sector-coupling and storage components (P2hydrogen, P2G, P2H, P2fuels (involving carbon capture), P2chemicals and vice versa; flex control of P2H conversions (Designed-4-Flex Heatpumps , etc).
5.3.2	Quantified potential benefits from storage in grids including storage and any other new technology (simulation: static and dynamic) (including in small self-consumption plants), to identify the storage needs and proper placements and taking into account grid investment deferrals (incl. remuneration schemes design for storage; including role of (virtual) rotating mass).
5.3.3	Technological challenges for the gas networks related to the large-scale application of power-to-gas.
5.3.4	Open source CBA (Cost Benefit Analysis) tools to compare storage with other flexibility means (network reinforcements and new lines, demand management, connections with other energy networks, flexible generation, etc.) including environmental and social aspects (LCA).
5.3.5	Energy storage systems integrated with conventional power generators such as cogeneration, hydropower, thermal plants to increase their flexibility and improve operation (incl. improvement of the effectiveness and load hours of combined heat and power units by introducing energy storage).
5.3.6	Storage duty cycle standards to give undisputed performance pre-qualifying certifications for market players using storage devices to provide system services
5.3.7	System services (balancing) brought from aggregated heating (and cooling) devices by network operators in case of low (or negative) residual loads when producing and storing thermal energy (flexibility potential at household / building / industry level rather than at equipment level. Consider also other forms of power-to-heat technology, like heat pumps, heat pump boilers).

Stakeholder Task No	STAKEHOLDER Tasks (January 2020) - ETIP SNET R&I Roadmap 2020-2030
5.3.8	Open Source simulation tools for understanding the dynamics of the coupled systems when producing large quantities of methane (power-to-gas) to be injected into the gas system (pipelines and underground storages).
5.3.9	Open source Software for selection and sizing of energy storage systems (also hybrid technologies) according to the applications (or services to provide) and their standardised characteristics (CAPEX, OPEX, cycling, lifetime, efficiency) in order to design cost-effective projects including energy storage. Use harmonised standards for definition and measurement of characteristics in order to facilitate comparisons among technologies; determine accurate and detailed parameters including for failure modes modelling and indicating standard cycling profiles (e.g. IEC 61427-2).
5.4.1	Standardised strategic HV (including Ultra-HV) components and HV system and multivendor applications for all PE (power electronics) interfaced devices (generation, load, and storage) connected to the distribution or transmission network (includes HV components (eg.110kV Voltage Level be operated through DSO's))
5.4.2	Controlled off- and onshore Wind-based power generation solutions for vendor-independent, HVDC multi-terminal networks used to coordinate power flow.
5.4.3	Flexibilities provided by distribution network reconfiguration
5.4.4	Smart inverters providing grid support functions
5.4.5	Increased on- and off-shore network controllability for optimal and coordinated use of flexible equipment such as FACTS, PSTs and HVDC links, superconductivity, energy storage, fault current limiters and other promising technologies using fibre-optic temperature monitoring and DL.
5.4.6	Power electronics at distribution level, smart transformers (power electronics OLTCs), open soft points, FACTS, etc.
5.4.7	Technical interoperability bodies: agree on new methodologies for capacity calculations of transmission and distribution grids considering new experience and the availability of additional data coming from DLR solutions

Stakeholder Task No	STAKEHOLDER Tasks (January 2020) - ETIP SNET R&I Roadmap 2020-2030
5.5.1	Centralized/distributed remote management systems and algorithms enabling smart grids integration of EV charging infrastructures, supporting business-to-customers and business-to-business relationships and ensuring easy and secure payments for customers (incl. roaming services).
5.5.2	Energy management in transport electricity network (railway, metro, tramway, trolleybus etc) to provide ancillary services to DSO via storage facilities in the substation of the PCC (point of common coupling).
5.5.3	Impact of transport system electrification (e.g., transport EVs, VtG, GtV, etc.) on distribution grids through reconfiguration, etc. for off-peak hours, and their use in system balancing.
6.1.1	Interactions between TSOs and DSOs: increase observability of the distribution system for transmission network management and controllability with better forecasting and data flow.
6.1.2	Open source Software for real-time RES observability (algorithms and tools) (including an update of the procured and activated reserves) and a better forecast of RES for operational planning purposes.
6.1.3	Open Source simulation tools for accurate state estimators using new monitoring devices (PMU, IoT, etc.).
6.1.4	Increased intelligence and autonomy at the HV substation level, and their link to state estimators and dynamic simulation tools.
6.1.5	Improved LV and MV monitoring and estimation using smart meter data from consumers.
6.1.6	Increased HV and MV system observability and state estimation accuracy by accurate HV and MV grid and protection system modelling (by merged HV transmission and MV distribution system models).

Stakeholder Task No	STAKEHOLDER Tasks (January 2020) - ETIP SNET R&I Roadmap 2020-2030
6.1.7	Intelligent HV system state estimation with intelligent sensors and data processing; new sensors for distributed observability of the transmission system (e.g., voltage sensors, load sensors, event sensors, temperature sensors, healthy sensors).
6.1.8	LV and MV monitoring combined with forecast algorithms to display the actual availability of network capacity.
6.1.9	Real-time models based on monitoring to achieve high quality state estimation and ensure reliable forecasts.
6.2.1	Algorithms to optimize Load Frequency Control including telecommunication needs and reliabilities
6.2.2	Models and open Source Software for associated simulation software for the study of distribution grids with very low (no) inertia, able to mimic the altered power quality, the modified dynamic behaviour of the power system, the possible interactions between the controllers of PE-interfaced generation units (and load), including harmonic distortion and power oscillations.
6.2.3	The contribution of RES to voltage and frequency control, to grid observability and grid protection as well as balancing, using different concepts, especially for direct-drive machines: VPP, inertia provided by the rotors, synthetic inertia provided by PE interfaced DER, PE-based reactive power control, local storage, etc.
6.2.4	Describe RES advanced functionalities and control strategies and validate
6.2.5	Validate and define more adapted and severe criteria of selection of technologies contributing to Short-term control. Insist on very short response time and separate primary and secondary control reserve.
6.3.1	Integrated generation forecasting from hydropower based on climate, weather and precipitation models and live .censoring.

Stakeholder Task No	STAKEHOLDER Tasks (January 2020) - ETIP SNET R&I Roadmap 2020-2030
6.3.2	Open Source simulation tools for expert systems for load and generation forecast, unit commitment, reserve allocation and optimal power flow considering uncertainties in the power system by applying artificial intelligence techniques and probability approaches.
6.3.3	Open Source SW for forecasting tools accounting for customer behaviour to predict EV charging loads.
6.3.4	Open source SW for the determination of effective and sufficient security margins during operation and operational planning.
6.3.5	Open Source simulation tools for improved RES forecast accuracy by hybrid approaches that combine weather forecasting, local ad-hoc models, historical data, and on-line measurement. Validate integration scenarios with services in which the network becomes more user-friendly and can cope with variable generation and secondary/tertiary reserves from RES.
6.3.6	Optimal load sharing between primary substations in real time depending on the local constraints, in particular at city level.
6.3.7	Dynamic capacity management and reserve allocation that support system operations with large amounts of RES integration.
6.3.8	Open Source simulation tools for accurate forecasting tools (generation and loads) at short-term time scales that are suitable for solving location-based grid constraints.
6.3.9	Tools (with advanced algorithms) taking advantage of the increased monitoring to optimise DSO topology (as a flexibility option in the operations).
6.3.10	Massive use of control technologies in secondary substations and the resulting coordination needs for the system and grid operators.

Stakeholder Task No	STAKEHOLDER Tasks (January 2020) - ETIP SNET R&I Roadmap 2020-2030
6.4.1	Security assessment for the various distribution-related energy carriers systems in case of outages in the distribution electricity network (e.g. electric pumps in the district heating and cooling networks, or in the drinking and wastewater networks, as well as electric compressors and control equipment in the gas network).
6.4.2	Open source Software for preventive and curative network operator actions (considering also natural catastrophes, terrorism and cyber-attacks; including failure modes of ICT and sensors).
6.4.3	Regulatory rules (coordinated with technical rules) for the implementation of grid restoration plans (after blackout or disturbances) at the pan-European level
6.4.4	Open source Software to support efficient and cost-effective DER contributions including wind and storage to pan-European (TSO) system black start restoration and immediate power reserves.
6.4.5	New equipment testing procedures for fault avoidance and fault analytics.
6.4.6	Web-of Cells: Optimized operation of MV and LV based on Artificial Intelligence systems, big data, and higher LV control (including identification of LV grid topology, and others).
6.4.7	Open Source simulation tools and methods for assessing the risk of breakdowns during reconnection and to detect weaknesses in the system with respect to reconnecting DER and storage systems.
6.4.8	Pan-EU or regional system restoration based on coordination of Tie Lines and/or Black Start units, whilst considering the system condition, system constraints and available resources to support the decision.
6.4.9	Customer risk handling (Risk-assessment of required level of reliability) based on probabilistic analyses of both normal and abnormal operations (including n-1), considering correlations in the power system.

Stakeholder Task No	STAKEHOLDER Tasks (January 2020) - ETIP SNET R&I Roadmap 2020-2030
6.4.10	Decision support regarding reactive power and voltage control, determination of loads when applying load shedding schemes, etc (including by means of system simulations, the objective of total shedding load in percentage of reference load, frequency stepping for a system with dispersed frequency relays implemented, number of load shedding stages in percentage of reference load, upper acceptable limits for the control time constants and delays).
6.4.11	Web-of Cells: Protection scheme underpinning the realisation of stable and efficient future power systems in radical new decentralized cell-based control architecture. (including proactive control of available grid resources to optimise protection functionality; and initiating post-fault action to ensure system stability and optimal system operation and network self-healing aptitude).
6.4.12	Minimized negative impact (or: maximise positive impact) of switching actions from one TSO to other TSOs.
6.4.13	Countermeasures for decreased distribution system short circuit current due to increased RES.
6.4.14	Operational scheduling tools for optimal grid configuration based on day-ahead forecasting and real network data to maximize (DER penetration) or minimize (network congestion), network losses, reverse power flows to TSO, etc
6.4.15	Open source Software for interactive system restoration tool (including RES and demand forecast, system state prediction).
6.4.16	Automatic LV and MV System Topology identification (topology of specific grid sections (e.g. output feeders, lines and/or phases of a secondary substation, etc.) and/or of specific grid components (switches/breakers position, etc.); in view of streamlining maintenance, failure location, grid reconfiguration, grid planning, etc).
6.4.17	Automatic fault clearing procedures with automatic power restoration.
6.5.1	Distributed Holistic Architecture (e.g. Web-of-Cell): New actuators (e.g. switches) and new sensors (e.g. fault detectors, voltage and current sensors; incl. in generation, storage, buildings, in EV, in industry, etc) allowing flexibility and new control strategies in a radically new decentralised network control architecture.

Stakeholder Task No	STAKEHOLDER Tasks (January 2020) - ETIP SNET R&I Roadmap 2020-2030
6.5.2	Monitoring and control coordination between LV and MV grids (including integration/coordination of LV and MV control rooms; integration to the customer premises/systems to allow their active participation in the energy market and in the grid operation optimization; interoperability with other actors (retailers, aggregators, TSOs) for grid status and data, in order to optimize and automate processes they cooperate; protocols to be applied for integration (e.g. 5G or Broadband PLC, etc.); Smart metering data processing and other Big Data applications.
6.5.3	Set-up and realisation of environments for most realistic training purposes to ensure stable and save distribution grid operation.
6.5.4	Indicators with quantification for resilience/ vulnerability and other criteria to help network operators make decisions for preventive and curative actions for long term/short term planning, Grid operation, Outage scheduling, all system operator tasks.
6.5.5	LV/MV human grid operator roles and intervention: Operate and monitor LV networks, optimizing and identifying network congestions, network losses, reverse power flows to TSO and act in a preventive and prescriptive way, in order to minimize and optimize human intervention (for forecasting, estimation and prediction of the grid status, performance and evolution (for instance, to foresee the lifecycle of the grid assets) allowing, e.g. grid automation modelling, scheduling and execution schemes, the improvement of the support to grid operators, preventive/predictive maintenance programming or grid assets planning (Solutions that prove to be applicable at a large scale and at low cost).
6.5.6	DSO Energy Management Platforms to manage the Distribution Networks by DSOs taking into consideration the links to TSOs and market (aggregators, retailers, etc.; including sharing experiences and recommendations for the implementation of new energy management platforms) considering the state of art of the ongoing projects (Coordinet, Interflex,..). New control room to handle complex decision-making situations including training.
6.5.7	Impact on ancillary services in the presence of large-scale DER integration: Products and services to be tested on selected segments of customers
6.5.8	Coordinated utilisation of WAMS (Wide Area Management Systems) information during operations and in critical situations.
6.5.9	Open source Software for efficient and cost-effective micro-grids with islanding capabilities.
6.5.10	Islanding with DER: Solutions to address technical, economic and regulatory dimensions of the interaction with local DER necessary for the islanding functioning (incl. smart secondary substations).

Stakeholder Task No	STAKEHOLDER Tasks (January 2020) - ETIP SNET R&I Roadmap 2020-2030
6.5.11	TSO Network Energy Management platforms (with the associated monitoring and control systems) able to interact with all local market players and with embedded functionalities such as self-healing capabilities for fault management. New control room to handle complex decision-making situations including training.
6.5.12	Real-time system implementation (digital twin) studies for electricity grids to improve system operation, management and development.
6.5.13	Transmission System Monitoring and Control Architecture: High-performance and high-speed communication infrastructure combined with sophisticated sensing technologies, automation and control methods.
6.5.14	Qualify and detect unwanted electrical islands. Propose innovative and sustainable alternatives in case of outages (e.g. mobile storage provided by DSOs).
6.5.15	Enhancement of MMI (Man-Machine-Interface) for short-term control in EMS
6.5.16	Open Source Software to reduce decision cycle time in decision-making analysis, especially in the case of increased variability, uncertainty of input data, and multiple conflicting evaluations.
6.5.17	Training of operators so as to adapt to Network Energy Management platforms (also for multi-energy carrier systems).
6.5.18	Active management and control using communication infrastructures at MV level restricted in bandwidth.
6.5.19	Validation of self-healing network solutions using smart controllers in smart secondary substations.

This publication has been developed in the frame of the INTENSYS4EU project,
which supports ETIP SNET activities and has received funding from the European Union's
Horizon 2020 research and innovation programme under grant agreement No 731220.

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