ETIP SNET

EUROPEAN TECHNOLOGY AND INNOVATION PLATFORM
SMART NETWORKS FOR ENERGY TRANSITION

Coverage analysis of the present roadmap (2017-2026)

February 2019

Coverage analysis of the present roadmap (2017-2026)

Authors: Dowel Management
Quality check: ZABALA, BACHER, RSE

Delivery date: February 2019

PLAN. INNOVATE. ENGAGE.

INDEX

INDEX OF IMAGES, TABLES AND FIGURES

FOREWORD AND EXECUTIVE SUMMARY

CONTEXT: ETIP SNET MONITORING ACTIVITY

The European Technology & Innovation Platform Smart Networks for Energy Transition (ETIP SNET) is guiding Research, Development and Innovation (RD&I) to support Europe's energy transition[1]. For that purpose, a 10-year RD&I roadmap covering 2017-26[2] was adopted in December 2016. It addressed not only smart electricity grids but also interactions with gas and heat networks and the integration of all flexibility solutions into energy systems, including energy storage and power conversion technologies.

The 10-year RD&I roadmap will be updated by 2020 to define the RD&I activities planned for the period 2021-2030. In this aim, a thorough assessment of recent and ongoing RD&I projects contributing to the activities planned within the roadmap, needed to be done. This is the purpose of the "monitoring activity" carried out by the INTENSYS4EU support team[3].

The objective of the monitoring activity is two-fold:

1. To analyse and to disseminate results from RD&I projects being in the scope of the ETIP SNET towards the energy community;
2. To measure the coverage degree of each RD&I item of the roadmap and decide which RD&I activities deserve to be maintained, and which are sufficiently well covered by results of recent and ongoing projects and could consequently be removed ("gap analysis").

The first sub-objective of the monitoring activity focusing on the analysis and dissemination of RD&I projects' results lying in the ETIP SNET scope has been published by the end of 2018[4].

The present report contributes to the second sub-objective of the monitoring activity by analysing in detail the degree of coverage of each RD&I item of the 10-year RD&I roadmap covering 2017-26.

STRUCTURE OF THE REPORT

The present report is structured as follows:

First an overview of the coverage assessment of the 10-year RD&I roadmap covering 2017-26 is provided with statistics regarding:

- The allocation of the 121 projects monitored between the Transmission / Distribution activities;
- The representativity of the experts involved among the energy system;
- The main outputs of the coverage assessment activity.

Then, the detailed coverage assessment for the Functional Objectives related to Transmission activities and the Distribution activities is presented.

[1] More information at https://www.etip-snet.eu/about/etip-snet/.

[2] Downloadable at https://www.etip-snet.eu/wp-content/uploads/2017/03/Final_10_Year_ETIP-SNET_RI_Roadmap.pdf.

[3] The INTENSYS4EU project supports ETIP SNET activities and has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731220. More information at https://www.etip-snet.eu/intensys4eu/.

[4] https://www.etip-snet.eu/wp-content/uploads/2018/11/Project_monitoring_Part1-Final-.pdf

MAIN OUTPUTS OF THE COVERAGE ASSESSMENT ACTIVITY

The share of coverage of the 10-year RD&I roadmap covering 2017-26 is illustrated by the figure below. This analysis reflects the point of view of the experts involved in this activity, based on their expertise and the 121 projects monitored in the first monitoring report activity[4].

The colour code used for the figure highlights:

- in **red** the share of activities considered as **Not addressed** by the experts and where more efforts and deeper research are needed;
- in **yellow**, the share of activities considered as **Partially addressed** by the experts where further demonstrations at larger scale shall be developed;
- and in **green** the share of activities considered as **Totally addressed** by the experts corresponding to activities fully implemented and with a high maturity level

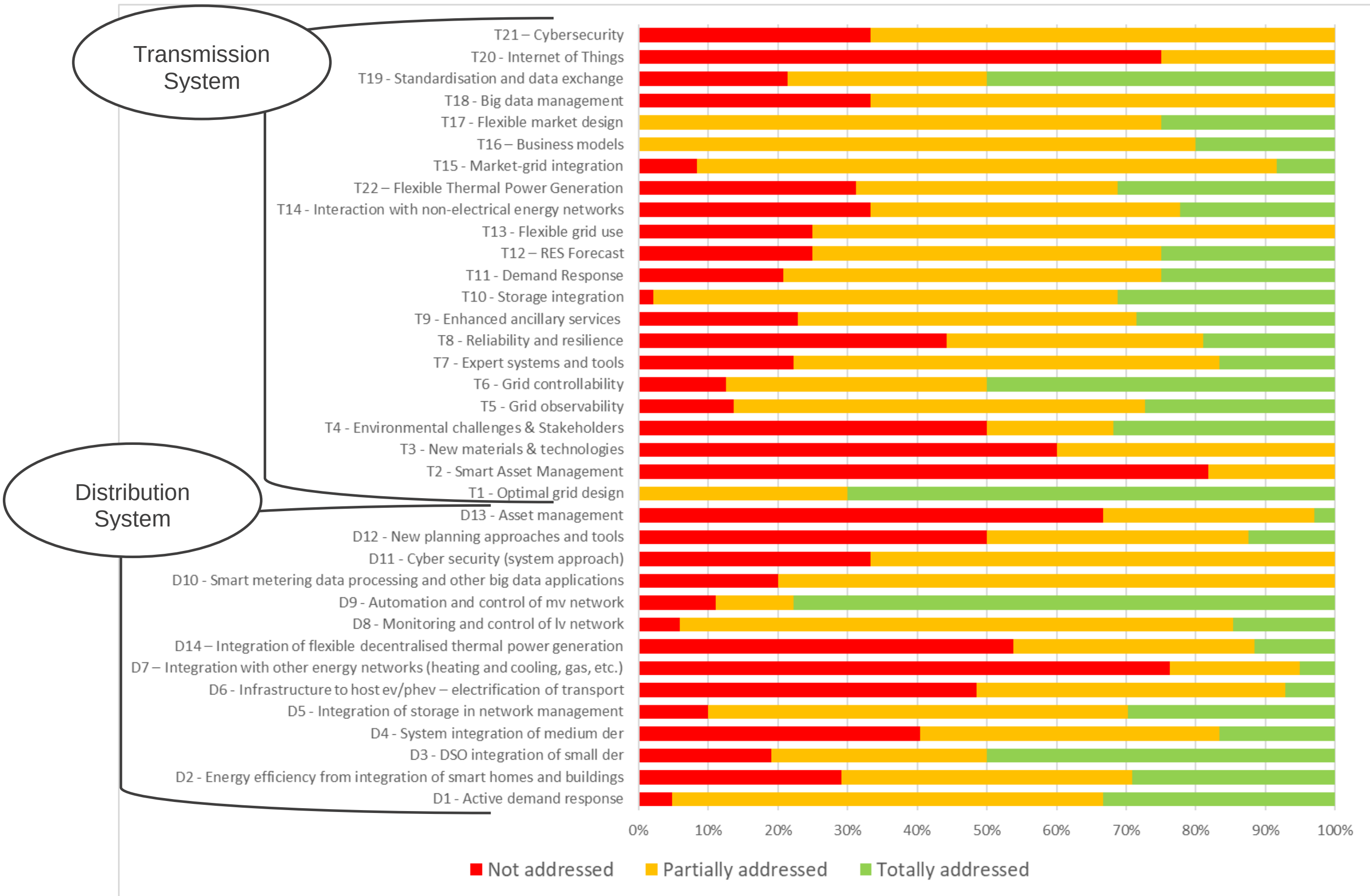


Figure 1. Overview of the coverage assessment.

Overall, six Functional Objectives have been assessed as **Not addressed** by more than 50% of the experts' inputs (T2, T3, T20, D7, D13 and D14). Experts mainly identified a significant need to dedicate more efforts and deeper researches to these specific activities.

Around half of the Functional objectives (16 Functional Objectives over 36) have been assessed as **Partially addressed** by more than 50% of the experts' inputs (T5, T7, T10, T11, T12, T13, T15, T16, T17, T18, T21, D1, D5, D8, D10, D11). For these operations, experts often considered that further demonstrations, at larger scale and in real conditions, are needed to properly cover all the scope of the activities.

Finally, two Functional objectives have been assessed as **Totally addressed** by more than 50% of the experts' inputs (T1 and D9). By inscreasing our view to the Functional Objectives with part of their activities assessed as **Totally addressed** (28 Functional objectives over 36), it can be pointed out that some experts considered development tools and activities as fully implemented and with a high maturity level, in line with the scope of the roadmap.

PART 1 –METHODOLOGY, PROJECTS AND EXPERTS OVERVIEW

STRUCTURE OF THE ETIP SNET ROADMAP (2017-2026)

List of clusters and functional objectives for transmission system

Based on the 10-year RD&I roadmap covering 2017-26[5], the list of Clusters and Functional objectives for the transmission system considered in the present report is reminded below:

Clusters	Functional objectives
Cluster 1 – Modernisation of the network	T1 - Optimal grid design
	T2 - Smart Asset Management
	T3 - New materials & technologies
	T4 - Environmental challenges & Stakeholders
Cluster 2 - Security and System Stability	T5 - Grid observability
	T6 - Grid controllability
	T7 - Expert systems and tools
	T8 - Reliability and resilience
	T9 - Enhanced ancillary services
Cluster 3 - Power system flexibility from generation, storage, demand and network	T10 - Storage integration
	T11 - Demand Response
	T12 – RES Forecast
	T13 - Flexible grid use
	T14 - Interaction with non-electrical energy networks
	T22 – Flexible Thermal Power Generation
Cluster 4 - Economic	T15 - Market-grid integration
	T16 – Business models
	T17 - Flexible market design
Cluster 5 - Digitalization of power system	T18 - Big data management
	T19 - Standardisation and data exchange
	T20 - Internet of Things
	T21 – Cybersecurity

[5] https://etip-snet.eu/pdf/Final_10_Year_ETIP-SNET_RD&I_Roadmap.pdf

List of clusters and functional objectives for distribution system

Based on the 10-year RD&I roadmap covering 2017-26[6], the list of Clusters and Functional objectives for the distribution system considered in the present report is reminded below:

Clusters	Functional objectives
C1 – Integration of smart customers and buildings	D1 - Active demand response
	D2 - Energy efficiency from integration of smart homes and buildings
Cluster 2 – Integration od decentralised generation demand, storage and networks	D3 - DSO integration of small der
	D4 - System integration of medium der
	D5 - Integration of storage in network management
	D6 - Infrastructure to host ev/phev – electrification of transport
	D7 – Integration with other energy networks (heating and cooling, gas, etc.)
	D14 – Integration of flexible decentralised thermal power generation
Cluster 3 – Network operations	D8 - Monitoring and control of lv network
	D9 - Automation and control of mv network
	D10 - Smart metering data processing and other big data applications
	D11 - Cyber security (system approach)
Cluster 4 – Planning and asset Management	D12 - New planning approaches and tools
	D13 - Asset management

METHODOLOGY APPLIED TO ELABORATE THE PRESENT REPORT

Phase 1: individual projects' coverage assessment

The 121 projects providing an input for the first sub-objective of the activity focusing on analysis and dissemination of RD&I projects' results, had also the opportunity to fill-in two online questionnaires in the aim of providing their individual coverage assessment of each RD&I item of the 10-year RD&I roadmap covering 2017-26[7].

The content of the questionnaires was based on the 10-year RD&I roadmap covering 2017-26. The two figures below illustrate the structure of the online forms:

[6] https://etip-snet.eu/pdf/Final_10_Year_ETIP-SNET_RD&I_Roadmap.pdf
[7] https://etip-snet.eu/pdf/Final_10_Year_ETIP-SNET_RD&I_Roadmap.pdf

Online Form 1: Contribution to the TRANSMISSION part of the ETIP SNET roadmap

and/or

Online Form 2: Contribution to the DISTRIBUTION part of the ETIP SNET roadmap

The ETIP SNET R&I roadmap 2017-2026 is structured along:

- CLUSTERS (for instance, "Modernisation of the network"),
- FUNCTIONAL OBJECTIVES (for instance, "Smart asset management"), and
- TASKS (for instance "To improve the modelling of rare, severe-impact events through inter-TSO collaboration on related data").

Figure 2. Structure of the online forms.

The Projects were firstly asked to which cluster(s) they contributed, then to which Functional Objective(s). For the selected Functional Objectives, the Projects screened the different tasks and answered a few questions as illustrated by the next figure.

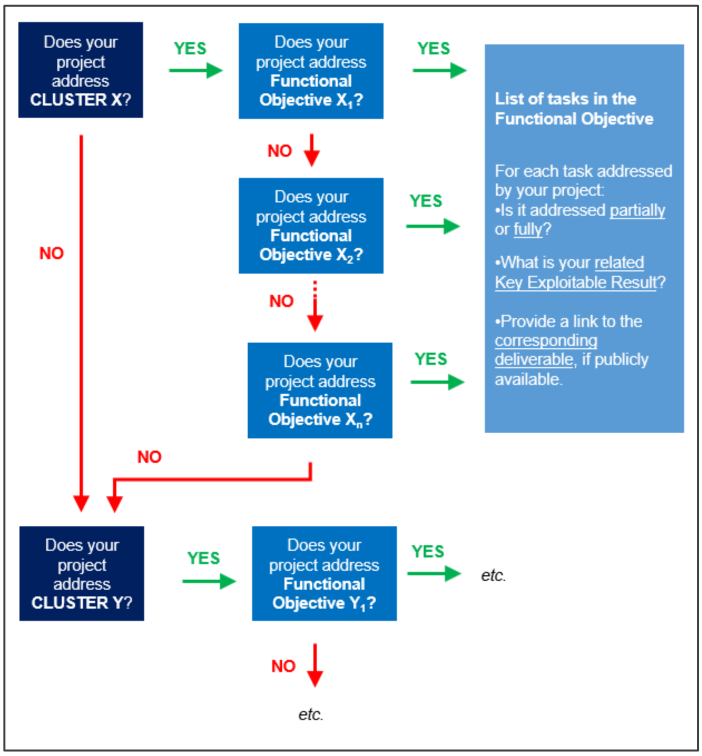


Figure 3. Flow chart for online forms related to Transmission and Distribution activities.

The allocation of the projects based on their inputs for the Transmission part and/or Distribution part of the RD&I item of the 10-year RD&I roadmap covering 2017-26 is provided in Annex 1.

Phase 2: coverage assessment by experts of the energy systems

Based on the projects' inputs and their expertise, more than 60 experts from the entire energy systems (throughout ENTSO-E, EDSO, EERA and EASE associations) were solicited to provide their final coverage assessment of the RD&I item of the 10-year RD&I roadmap covering 2017-26. For each RD&I item, the experts were requested to provide four level of information:

1. Their expert's views regarding the final assessment of the coverage of the roadmap's tasks (Totally addressed / Partially addressed / Not addressed);
2. The justification of their assessment based on the tools/methodologies developed or not within the projects listed or beyond;
3. If a task was assessed as Partially addressed or Not addressed, the experts were requested to indicate whether they would suggest a merge, reformulation or a new task;
4. Based on the information provided in 3), a proposal of evolution could be indicated.

Phase 3: concatenation of experts' inputs

The last phase to elaborate the present report was to analyse the inputs provided by the experts and illustrate the different positions and complementarities of the assessements. Moreover, for each Functional Objective, a final conclusion based on the experts' inputs and including statistics has been elaborated.

The display of the information for each Functional Objective all along the present report is the following:

CLUSTER X – TITLE OF THE CLUSTER

T/DX – Title of the Functional objective

List of the Tasks included in this functional objective

This part provides in detail the list of the tasks included within the dedicated Functional Objective as indicated in the 10-year RD&I roadmap covering 2017-26.

List of projects considered

This part provides the list of projects (FP7/H2020 or Other projects) having participated in the survey and claiming to contribute to Functional Objective X.

List of experts consulted

This part indicates the name of the experts who provided their expert views regarding to which extent the results from the projects considered (and beyond) contribute to cover the tasks listed within Functional Objective X.

Overview of the coverage of the Functional Objective according to experts' views

This section displays the experts' assessments for the coverage of the Functional Objective X and highlights the differences and complementarities by task.

Overall achievements reached under this Functional Objective

Based on the experts' inputs, this part stresses the main achievements reached for each task of the Functional objective assessed as fully or partially addressed.

Main gaps to cover this functional objective

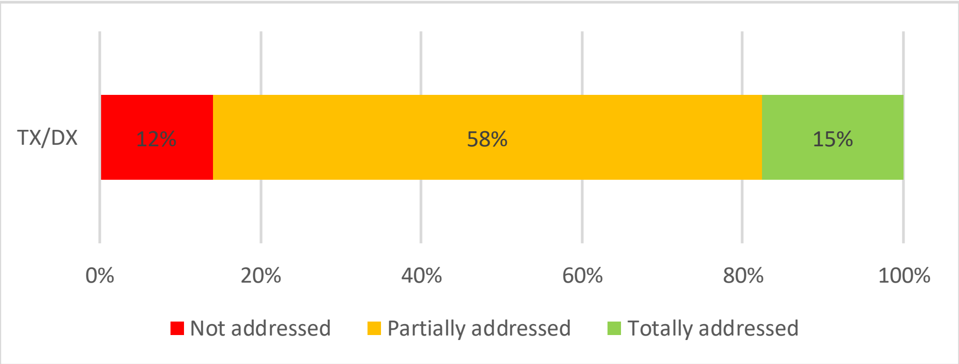
Based on the experts' inputs, this part highlights the main gaps to be fulfilled for each task of the Functional objective assessed as partially or not addressed.

Proposal of evolution for the tasks

Based on the experts' inputs, several proposals of evolution for the tasks have been provided: removal, reformulation, merge or new tasks.

General conclusion for the coverage of the functional objective

This final box highligths the main conclusions regarding the coverage assessement at the level of the Functional objectives and displays the final coverage of the Functional Objective based on the experts' inputs (see example below).



INDIVIDUAL PROJECTS ALLOCATION

On the 121 projects described and introduced in the first sub-objective of the monitoring activity focused on the analysis and dissemination of RD&I projects' results published by the end of 2018[8], a total of 91 different projects provided an input for the coverage assessment of the 10-year RD&I roadmap covering 2017-26. The list of the projects are reminded in annex 1.

Clusters and Functional objectives related to Transmission activities

Overall, 55 different projects provided inputs for the coverage assessment of the Functional objectives related to Transmission activities. The allocation of projects depending on the cluster and the Functional objective is illustrated in the graph below (considering that one project can cover several Functional objectives):

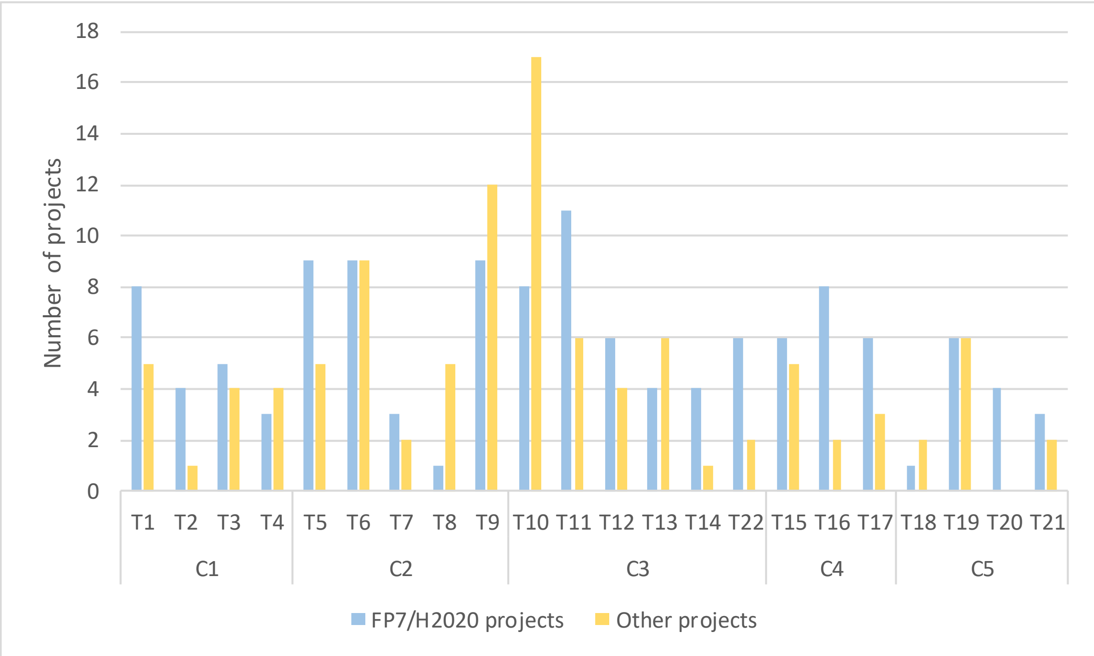


Figure 4. Allocation of projects for the coverage assessment of the Functional objectives related to Transmission activities.

In summary, the coverage assessement of the functional objectives related to Transmission activities has been provided for 55% by FP7/H2020 projects, and for 45% by Other projects.

Clusters and Functional objectives related to Distribution activities

In total, 57 different projects provided inputs for the coverage assessment of the Functional objectives related to Distribution activities. The allocation of projects which provided an input depending on the cluster and the Functional objective is illustrated in the graph below (considering that one project can cover several Functional objectives):

[8] https://www.etip-snet.eu/wp-content/uploads/2018/11/Project_monitoring_Part1-Final-.pdf

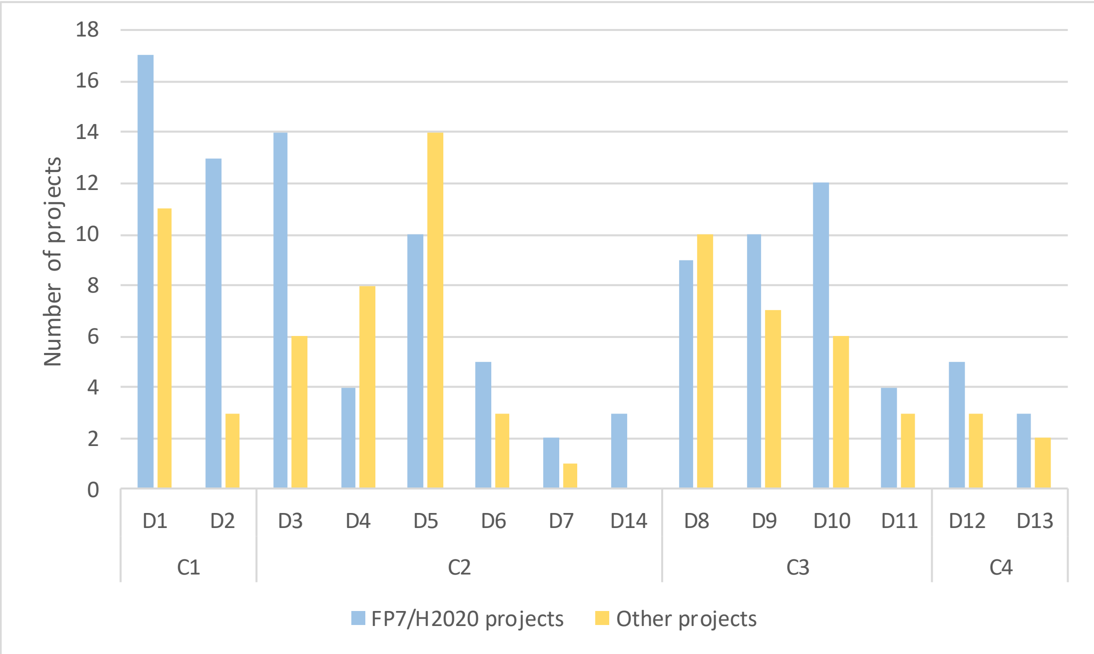


Figure 5. Allocation of projects for the coverage assessment of the Functional objectives related to Distribution activities.

In summary, the coverage assessement of the functional objectives related to Distribution activities has been provided for 60% by FP7/H2020 projects, and for 40% by Other projects.

EXPERTS' OVERVIEW

Overall, experts coming from more than twenty different entities have provided an input for the coverage assessment of the 10-year RD&I roadmap covering 2017-26. Their allocation is based on four main categories:

- **Network operators**: transmission and distribution systems;
- **Universities and research centres**;
- **Industries**;
- **Other**: consultant, etc.

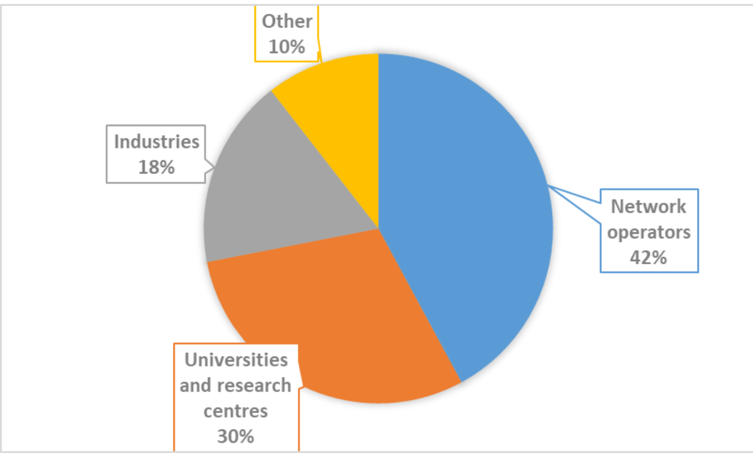


Figure 6. Allocation of experts for the coverage assessment of the Functional objectives related to Transmission activities.

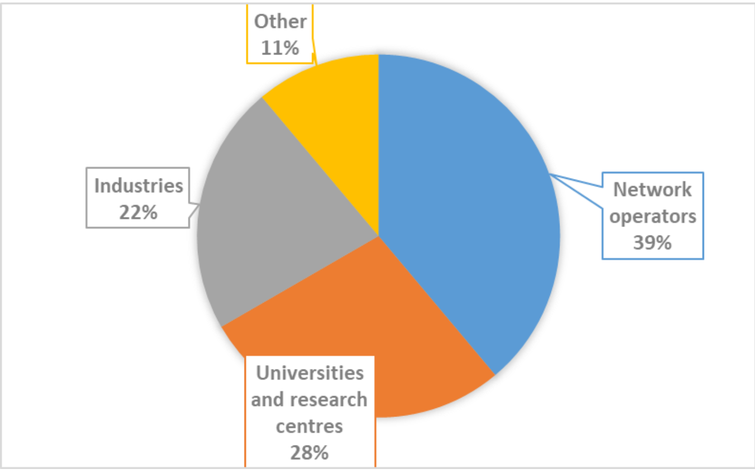


Figure 7. Allocation of experts for the coverage assessment of the Functional objectives related to Distribution activities.

The allocation of experts for the coverage assessment of the 10-year RD&I roadmap covering 2017-26 is in the same order of magnitude between the Transmission and Distribution topics: about 40% of the experts come from network operators, 30% from the Universities and research centres and 20 % from industries.

PART 2 – COVERAGE ASSESSMENT FOR THE FUNCTIONAL OBJECTIVES RELATED TO TRANSMISSION ACTIVITIES

CLUSTER 1 - MODERNISATION OF THE NETWORK

T1 – Optimal grid design

List of tasks included in this functional objective

1. To investigate state-of-the-art planning methodologies and software, technology portfolios and different regulatory frameworks
2. To develop 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
3. To develop planning software to optimize location, coordination, control and integration of technologies within the existing and future system architecture and operation
4. To develop planning methods that combine electricity market analysis, production capacities (all kinds, including DER), demand response capacities and infrastructure, storage, and environmental constraints, both at the transmission and distribution levels, with the aim of strengthening expected weak points on the grid
5. To develop probabilistic planning methods that respect the variability of RES, demand response, storage, self-consumption, and their uncertainty
6. To propose network investments at the EU level
7. To take into account the expected coordination levels at transmission level and develop a top-down network development approach involving regional initiatives to avoid extra investments or lower system reliability
8. To account for coupling with other energy networks (especially gas but also heat and cold) in the planning studies (simulations), e.g., dynamic coupling between gas and electricity networks
9. To account for maintenance operations in the new planning tools (the system must remain operable when maintenance operations are performed)
10. To develop modular infrastructures, both in term of size/capacity and in terms of voltage level

List of projects considered

The following projects have participated in the survey and claimed to contribute to Functional Objective T1.

FP7/H2020 projects		**Other projects**	
eBADGE FLEXITRANSTORE	INTERPLAN MIGRATE	3D DSS ADOSA NEXUS	SINCRO.GRID SIREN

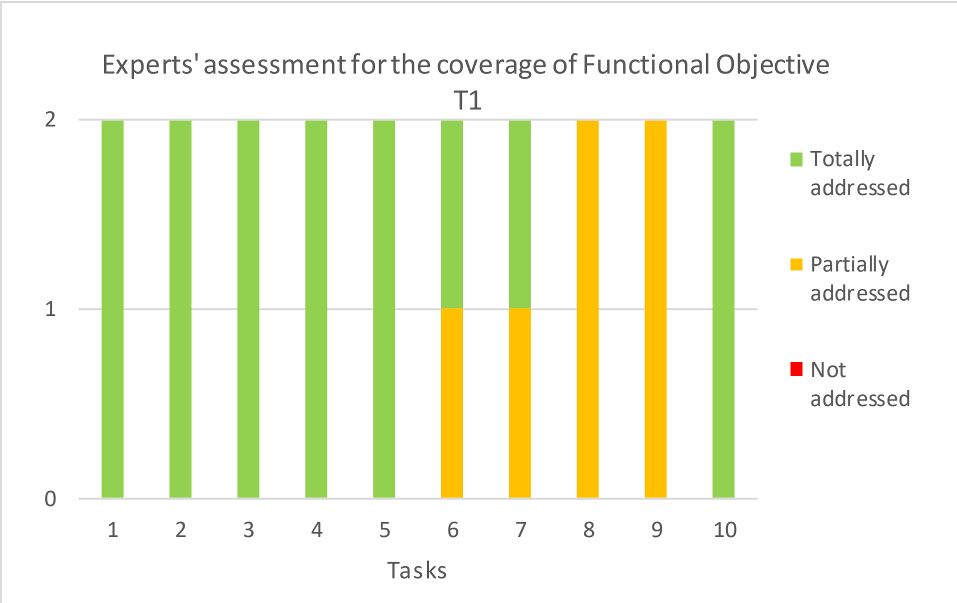
List of experts consulted

The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective T1.

Organisation	Name
TERNA	Antonio Iliceto
TRACTEBEL	Niels Leemput

Overview of the coverage of the Functional Objective according to experts' views

Two tasks have been assessed as partially addressed by all the experts (**tasks 8 and 9**), while two other tasks have been considered as partially or totally addressed (**tasks 6 and 7**). Remaining tasks, which represent over half of the T1 tasks, are judged as totally addressed by all the experts.



Overall achievements reached under this Functional Objective

Regarding **task 1**, different projects such as 3D DSS, INTERPLAN or MIGRATE, addressed, the most important aspects of this topic, in particular planning methodologies, software, technology portfolios and different regulatory frameworks.

3D DSS and ADOSA projects specifically developed cost benefit analysis for the **task 2**, thanks to multi criteria approach and assessment of storage benefits compare to other solutions.

3D DSS, INTERPLAN and PLAN4RES addressed satisfactorily the **task 3**. For instance, INTERPLAN developed a planning methodology of the pan-European electricity network, able to go down to the end user, and to allow active contributions throughout the network.

Task 4 has been addressed by listed projects like SUNSEED and SIREN, which developed technologies to assess the need of storage capacity in the grid, and other flexibility measures.

Considering **task 5**, INTERPLAN investigated on some of the research outcome of GARPUR[9] project including the proposed reliability criteria and reliability management methodologies across different TSOs in Europe.

[9] Generally Accepted Reliability Principle with Uncertainty modelling and through probabilistic Risk assessmentis

Regarding **task 6**, MIGRATE set to develop a cost benefit analysis to estimate investments to get a robust grid with a high amount of Power Electronics devices. But expert also consider that this task in not a typical R&D topic and more relevant for infrastructure investment phase.

Task 7 has also been covered by INTERPLAN project as developer provides an operation planning tool designed by taking into account all voltage levels in an integrated top-down approach, going from high voltage to low voltage up to end-consumer.

Considering **task 8**, projects such as RealValue asked to academic partners to produce detailed power system and energy market models (validated by the demo results) which can be exploited to introduce more RES into the grid, integrate more storage technologies.

Task 9 co-optimised planning and asset management phases, which is between functional objectives T1 and T2, and could be monitored also in T2.

Regarding **task 10**, INTERPLAN developed an integrated control system logic that can be applied on other grid areas and different voltage levels, thereby representing a source for further development and integration.

Main gaps to cover this functional objective

Experts considered that **tasks 1, 2, 3, 4, 5 and 10** have been well covered by existing projects, no further research in the near future seems to be mandatory for these tasks.

Expert doubts of the relevant character of the **task 6** in the functional objective.

Task 7 would deserve more attention in future R&D projects, in the workstream of TSO-DSO cooperation. It is needed that TSOs and DSOs fostered at regional level to propose R&D projects in this topic.

Task 8 would deserve more attention in future R&D projects, in the workstream of cross-sector coupling. It is needed that other energy carriers' operators fostered at regional level to propose R&D projects in this topic.

Foster TSOs to propose joint planning-operation-asset management departments working together in the **task 9**.

Proposal of evolution for the tasks

Tasks 1, 2, 3, 4, 5 and **10** could be deleted as objectives have been reached.

Task 6 could be droped from the functional objective.

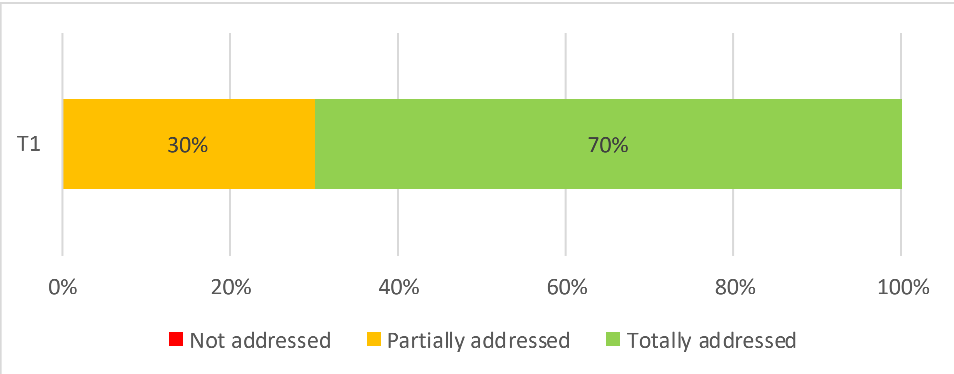
Task 7 and **8** shall be further studied by listed projects.

Task 9 could be reformulated as "To account for maintenance operations in the new planning tools and include them in the assessment".

General conclusion for the coverage of the functional objective

- Overall, experts considered that a majority of the tasks has been totally addressed by the listed projects, through the development of control systems and other methodologies.
- Two tasks requested further research to be perfectly covered as only few projects touched on their topics
- In terms of evolution for the tasks: six tasks could be deleted as their topic has been properly treated or it was not appropriate in this functional objective; reformulation is requested for one task.

⇨ **Final coverage of the Functional objective:**



T2 – Smart asset management

List of tasks included in this functional objective

1. To identify parameters (climate conditions, operating conditions, potential for hardware and software, among others) that impact the lifespan of components
2. To establish evaluation/estimation protocols for component conditions that are comparable across TSOs, with in-depth analysis and shared experiences
3. To validate the added value of individual lifetime assessments compared to an average assessment of several similar components based on generic parameters (age of equipment, switching steps, etc.)
4. To develop new ways of detecting component failure based on failure models (probabilistic models)
5. To develop software for estimation of component real life time (to be checked vs manufacturer declared lifetime), based on set of historical data of measured operation conditions (voltage, load, frequency) since in operation
6. To integrate new sensors and new equipment condition monitoring approaches based on distributed technologies
7. To implement robotics for automated condition monitoring or diagnostic systems for incipient problem detection, as well as to intervene in hostile environments and avoid the need for human maintenance. Also includes live line maintenance and working practices and the use of drones for network monitoring
8. To propose scaling up and replication rules for new asset management approaches at the pan-European level
9. To improve the modelling of rare, severe-impact events through inter-TSO collaboration on related data
10. To improve methodologies, methods and software for physical protection of the grid infrastructure and protecting against natural catastrophes, terrorism, cyber-attacks
11. To link with standardisation is key in terms of assessing the validity of the diagnostic methodologies investigated, validating the measuring chain, and ensuring the safety of operation (especially for live line work)

List of projects considered

The following projects have participated in the survey and claimed to contribute to Functional Objective T2.

FP7/H2020 projects		Other projects
FLEXITRANSTORE GRIDSOL	RealValue RESERVE	SIREN

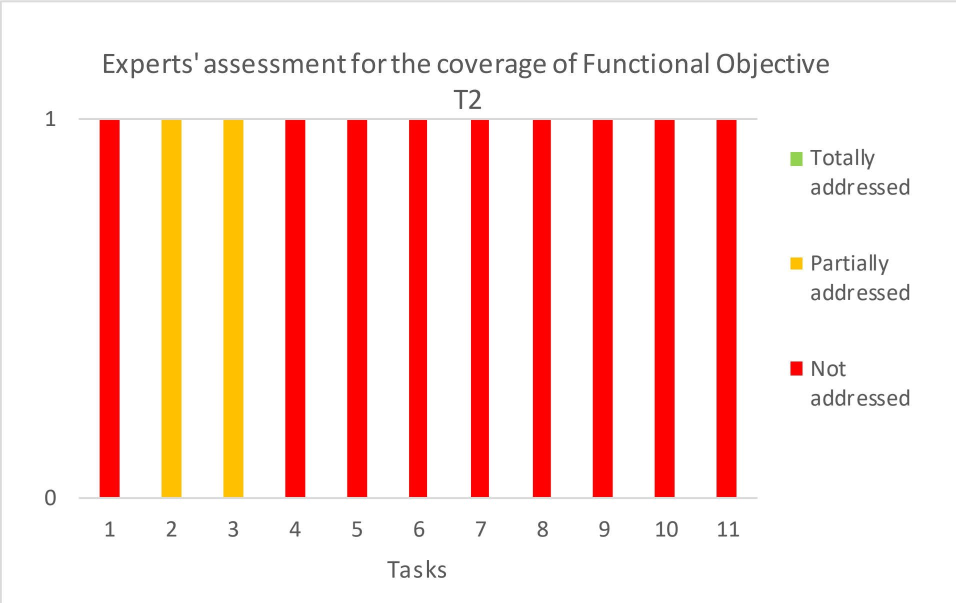
List of experts consulted

The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective T2.

Organisation	Name
TERNA	Antonio Iliceto

Overview of the coverage of the Functional Objective according to experts' views

Only one expert sent his assessment on the tasks. There are just **tasks 2 and 3** which were partially covered according to the expert, while other tasks were not addressed.



Overall achievements reached under this Functional Objective

Considering **tasks 1, 4, 5, 6, 7, 8, 9, 10 and 11**, they suffered a lack of covering on the issue from an asset management perspective.

Regarding **tasks 2 and 3**, RealValue and SIREN covered very partially the topic according to the expert and their topics deserved further developments.

Main gaps to cover this functional objective

Overall, the expert consulted estimated that the eleven tasks have not been sufficiently treated by listed projects and needs deeper research to cover the existing gaps.

Proposal of evolution for the tasks

The following tasks could be merged:

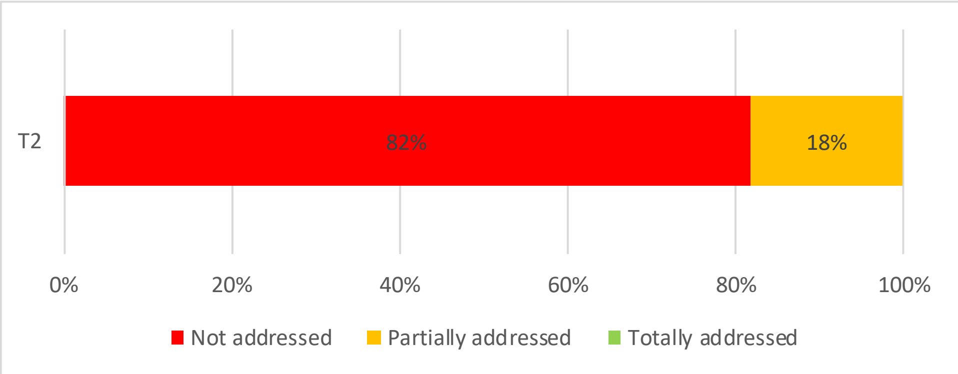
- **Tasks 1, 2, 3** and **5**;
- **Tasks 4, 6** and **7**;
- **Tasks 8** and **11**.

Tasks 9 and **10** could be moved in the functional objective T8 about reliability and resilience.

General conclusion for the coverage of the functional objective

- Only one expert sent his assessment on the smart asset management topic. According to him, most of the tasks have not been addressed by listed projects (nine tasks out of eleven).
- Two tasks have been partially addressed and need further developments.
- In terms of evolution for the tasks: nine tasks could be merged and be reshaped in three tasks; two tasks could be repositioned in the functional objective T8.

⇨ **Final coverage of the Functional objective:**



T3 – New materials & technologies

List of tasks included in this functional objective

1. To demonstrate the degree to which transfer capacity and asset performance can be increased through the implementation of different approaches (materials) and technologies. Assessment of new storage technologies
2. To investigate emerging technical solutions in the construction of new infrastructure and maintenance of existing networks, and perform cost benefit analysis of different case studies
3. To demonstrate controllable off- and onshore solutions for vender-independent, HVDC multi-terminal networks used to coordinate power flow
4. To investigate the influence of parallel routing of DC and AC lines in the same tower or parallel paths to facilitate existing infrastructure paths in an optimal manner
5. To develop the technologies to coordinate with storage infrastructure and gas and heat networks
6. To investigate lower and higher frequency networks as an alternative to DC links
7. To standardise strategic components and system and multivendor applications for all PE interfaced devices (generation, load, and storage) connected to the transmission network
8. To develop superconductor Fault Current Limiter in order to avoid strong Short Circuit currents in the new grid architectures
9. To assess the need for new components and systems to reduce the effect of extreme environmental stressors (extreme winds, rapid rainfall, storms, floods, wet snow, saline pollution etc.), both for AC and DC applications
10. To assess the possibility of substituting SF6 in stations equipment and circuit breakers with a suitable and environmental-friendly substance

List of projects considered

The following projects have participated in the survey and claimed to contribute to Functional Objective T3.

FP7/H2020 projects	Other projects
FLEXITRANSTORE GRIDSOL INTERPLAN RealValue RESERVE	Hybrid HVAC / HVDC overhead lines in Switzerland NEDO NEXUS STENSEA

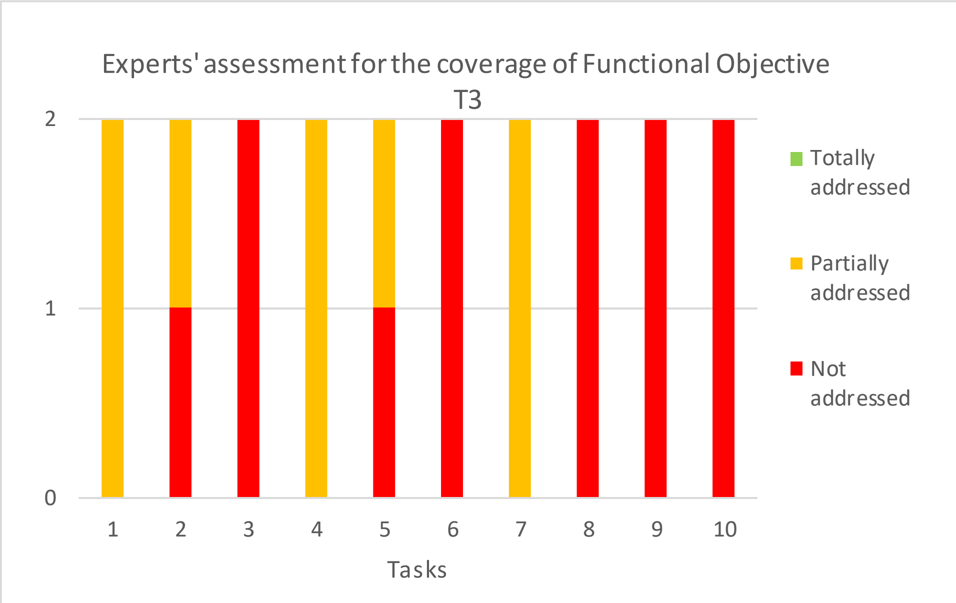
List of experts consulted

The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective T3.

Organisation	Name
SINTEF	Andrei Z. Morch
TERNA	Antonio Iliceto

Overview of the coverage of the Functional Objective according to experts' views

Half of the tasks have been unanimously assessed as not addressed by the experts (**tasks 3, 6, 8, 9 and 10**). Three tasks have been considered as partially addressed by all the experts (**tasks 1, 4 and 7**), while two others have been judged as partially or not addressed (**tasks 2 and 5**).



Overall achievements reached under this Functional Objective

Regarding **task 1**, ongoing projects like NEDO and STENSEA investigated storage technologies with renewable energy, but they mostly focused on system and not on approaches and materials. INTERPLAN is partially working on flexible demand response and answered to **task 2**, however it is still unclear how this is related to construction of new infrastructure.

Task 4 has been covered by Hybrid HVAC/HVDC project, which investigate the possibility of achieving significant power transmission increases through the conversion of existing 380 kV overhead transmission lines in Switzerland to hybrid AC/DC transmission systems.

Ongoing projects have some activities linked to **task 5**, such as RESERVE that studies storage infrastructure in the context of frequency stabilization simulations and concepts.

GRIDSOL project is concerned by **task 7** as it works on standardization of energy management system. Also MIGRATE project (not included in this list), investigates deeply the topic.

Regarding **task 9**, the effect of extreme climate events is limited by the scope of Hybrid HVAC / HVDC project. Thus, no broad identification of extreme climate events as increasing threats to the transmission system is found.

Main gaps to cover this functional objective

New materials and processes deserve investigations for wide utilization regarding **tasks 1 and 2**.

Use cases are different for the **task 4**, so more projects are requested to address possibly different configurations.

Task 6 has ambitious target but still very theoretical, it should be invetigated with low TRL by Academia according to the experts.

Regarding **task 10**, rather than R&D program, more demonstration/field tests are needed according to the experts.

Proposal of evolution for the tasks

Tasks 1 and 2 could be merged.

Task 3 could be moved in the functional objective T6 about grid controllability.

Task 5 could be moved in the functional objective T14 about interaction with non-electrical energy networks.

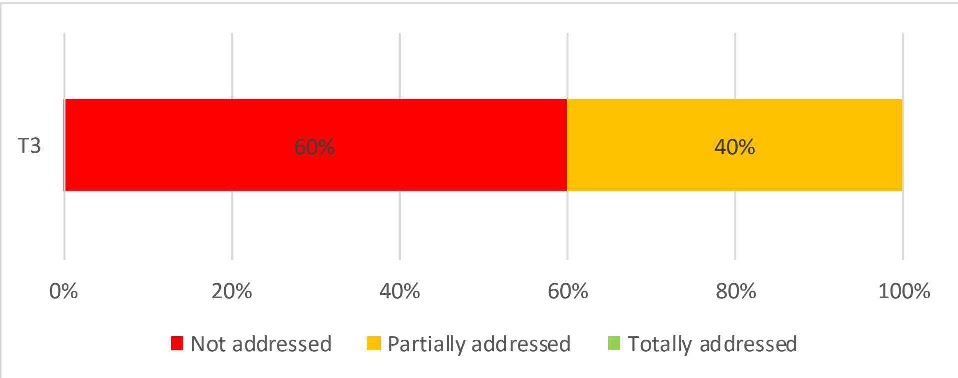
Task 9 could be moved in the functional objective T8 about resilience.

Tasks 4, 6, 7, 8 and 10 shall be further studied.

General conclusion for the coverage of the functional objective

- Half of the tasks have not been addressed at all according to the two experts surveyed. These projects need to make a step towards, passing from R&D program to demonstration/field tests, among others.
- No task has been assessed as fully addressed, as remaining tasks have been judged as partially addressed mainly due to a lack of experimentations.
- In terms of evolution for the tasks: three tasks could be moved in other functional objective; two tasks could be merged.

⇨ **Final coverage of the Functional objective:**



T4 – Environmental challenges & Stakeholders

List of tasks included in this functional objective

1. Increase communication campaigns, develop social impact studies and increase the involvement of local and territorial bodies in the early stage of planning of the infrastructure
2. Deepen studies on human and animal exposure to EMF
3. Develop holistic approaches for maintenance accounting of the environmental (e.g., tree growth rate, wind) and operational (e.g., hazard rate) effects on assets' lifetime
4. Analyse new technologies that have reduced conductor visibility and reduced sag
5. Propose new tower and stations designs with less visual impact, audible noise and EMF
6. Implement pilot projects for demonstration and assessment of the methodologies and software developed to protect the grid infrastructure
7. Conduct pilot projects concerning the implementation of the guidelines for improving the relationship between TSOs and the public, namely consumers
8. Investigate the environmental impact of partial undergrounding solutions (cables) and new technologies
9. Update the European guidelines on good practice in transparency and public engagement and the permit process
10. Produce guidelines for the construction and maintenance of overhead lines, with the goal of improving public acceptance
11. Mapping bird-sensitive areas and developing new bird savers to minimize birds collision and nurturing bird nests

List of projects considered

The following projects have participated in the survey and claimed to contribute to Functional Objective T4.

FP7/H2020 projects	Other projects
GRIDSOL INTERPLAN RealValue	3D DSS ALEGRO CECOVEL NEDO

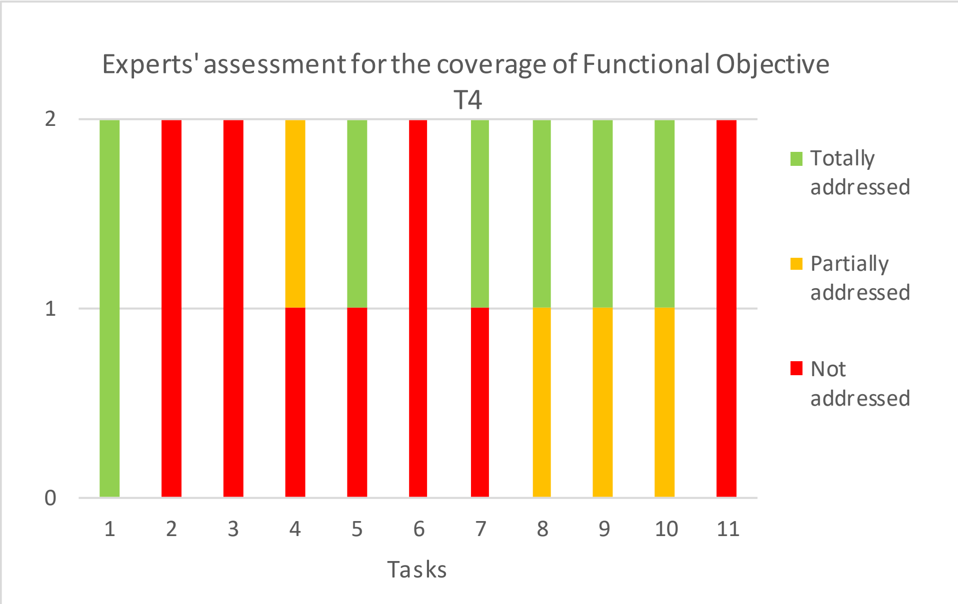
List of experts consulted

The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective T4.

Organisation	Name
SINTEF	Atle Harby
TERNA	Antonio Iliceto

Overview of the coverage of the Functional Objective according to experts' views

Three tasks have been considered as not addressed by both experts (**tasks 2, 3 and 6**), while another one has been judged as partially or not addressed (**task 4**). Three others have been assessed as partially or totally addressed (**tasks 8, 9 and 10**), and one as fully addressed by all the experts (**task 1**). Two tasks presented divergent assessment with one expert considering the task as totally addressed and another as not addressed (**tasks 5 and 7**).



Overall achievements reached under this Functional Objective

Many projects such as 3D DSS or INTERPLAN addressed **task 1** as well as practical implementations.

Regarding **task 2**, study has been done using the current legal limits for Electro Magnetic Field (EMF) in a tool, but not about human exposure to EMF.

Considering **task 3**, tools and methodologies currently developed in 3D DSS or GRIDSOL projects are more focused on planning and implementation and not in Operation & Maintenance.

Few projects covered **tasks 4 and 7** like ALEGRO, Cecovel or 3D DSS, but globally there is a lack of information or experience to properly assess.

Experts are divided on the **task 5** as one estimated that ALEGRO and many more projects, as well as practical implementations by TSOs have addressed.

Only 3D DSS project partially addressed **task 7**. Experts are divided as one of them estimated that projects and practical implementations by TSOs addressed this task, while the other expert estimated that the task need way more attention as no pilot is established now.

Regarding **task 8**, 3D DSS developed optimization for modelling underground cables, with an approach that computes the optimal corridor and path for underground cables and combines it with an overhead line.

Considering **tasks 9 and 10**, 3D DSS project developed a tool to assess transmission line corridor.

Main gaps to cover this functional objective

Regarding **task 1**, the issue is now more on exchanging experiences and best practices rather than more implementing R&D projects. Communication and involvement of stakeholders is an on-going process that always can be improved according to the experts.

Task 2 is important according to the experts, and studies promoted should be driven by research Centers (using grid operators' field equipment for testing purposes).

Considering **task 3**, maintenance is important especially for environmental impacts and impacts in the power line corridor. These corridors can be turned into ecological important corridors with the approproate management. With increasing risk of natural hazards, high winds, or heavy snowfall, improved assessments of hazards, mitigation measures and lifetme assessments are needed.

Many experimentations on conductor visibility and reduced sag need to be developed to increase **task 4** coverage.

Regarding **task 5**, issue is probably now more on exchanging experiences and best practices rather than more R&D projects.

Methodology and software seem to be ready for **task 6**, next step will consist to establish pilot.

Exchanging experiences and best practices is very relevant for **tasks 7 and 9**, but not as an R&D project.

Considering **task 8**, more case studies are needed to complete the topic. Updating guidelines is the natural next step after testing and evaluating the tools.

Proposal of evolution for the tasks

Task 1 could be:

- deleted as objectives have been reached;
- merged with **tasks 7, 9 and 10**.

Task 3 could be:

- deleted the task as subject is not clear;
- further studied.

Task 4 could be:

- deleted the task as subject is not clear;
- merged with other task.

Task 5 could be:

- deleted as objectives have been reached;
- reformulated to clarify the task.

Task 6 could be moved in the functional objective T8.

The following tasks could be merged:

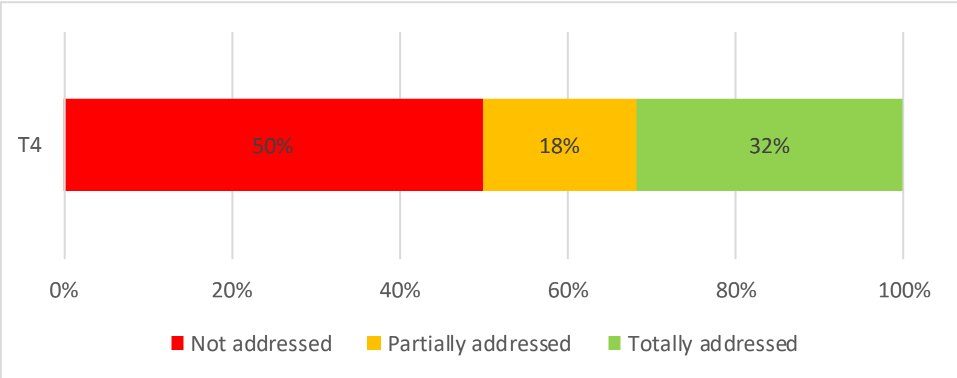
- **Task 7** with **tasks 1, 9 and 10**.
- **Task 9** with **tasks 1, 7 and 10**.
- **Task 10** with **tasks 1, 7 and 9**.

Tasks 2, 5, 8 and 11 shall be further studied.

General conclusion for the coverage of the functional objective

- Over one third of the tasks have been assessed as not addressed by all the experts, as no tool or methodology linked to their topic have been developed so far.
- One task has been perfectly covered by listed projects, while three others still need additional experimentations to cover their whole subjects.
- In terms of evolution for the tasks: four tasks could merge between them; four others need to be further studied; rest of the tasks could be deleted or reformulated, as their objectives have been reached or their subjects are not clear.

⇨ **Final coverage of the Functional objective:**



CLUSTER 2 - SECURITY AND SYSTEM STABILITY

T5 – Grid Observability: PMU, WAM, Sensors, DSO information exchange

List of tasks included in this functional objective

1. Assess and validate the performance of intelligent local sensors and data processing equipment (with sensor manufacturers) against the requirements for state estimation and dynamic simulation
2. Develop tools utilising new sensors for distributed observability of the transmission system (e.g., voltage sensors, position sensors, event sensors. These are very cheap and simple to use in a distributed approach, and can derive conditions and state estimations from statistical analysis of the acquired data.)
3. Optimize the existing toolbox to increase the awareness of pan-European operation, allowing for optimisation of local and regional approaches
4. Develop local state models with a sufficient level of intelligence and autonomy at the substation level, and link them with state estimators and dynamic simulation tools. These models will be aggregated to assess the observability at the required level, and should help infer automatic rules for operations at the local level (decentralised intelligence)
5. Increase observability and improve state estimation accuracy (both steady-state and dynamic) through adequate modelling (not only through modelling protection and automatic system schemes, but also by merging transmission and distribution models)
6. Exploit the information provided by forecasts of variable generation and flexible demand for observability purposes
7. Enhance the TSO/DSO communication interface and design new architecture for data exchange and processing at various system levels, e.g., TSO/DSO boundary substations, and in different time frames, from short-term to long-term, i.e., from real-time operational planning to network planning
8. Investigate and develop methodologies, procedures, protocols, standards and tools for inter-TSO communication, in view of determining the amount and type of data exchange which is required to enable an extension of the observable area to neighboring TSO, and, ultimately, to provide detailed and accurate data to regional initiatives. This should aim at mitigating possible negative impact of switching actions from one TSO to other TSOs, and at finding possible efficient cross border remedial actions
9. Investigate and develop the methodologies, procedures, protocols, standards and tools for inter-TSO communication, which will determine the amount and type of data exchange required to enable an extension of the observable area to neighbouring TSOs. The aim is to mitigate a possibly negative impact of switching actions from one TSO to other TSOs
10. Develop effective data-mining algorithms capable of extracting important information in real time from massive amounts of data
11. Implement solutions for WAMS and demonstrate how to utilize such information in a coordinated manner during operations. Observability should also be seen from the operators' point of view, i.e., how to operate a network in new situations with new sets of information resulting from increased data and new tool availability. Critical situations might become even more complex as operations become increasingly automated.

List of projects considered

The following projects have participated in the survey and claimed to contribute to Functional Objective T5.

FP7/H2020 projects		Other projects
eBADGE FLEXITRANSTORE GRIDSOL INTERPLAN MIGRATE	OSMOSE PLAN4RES RESERVE SUNSEED	LIVING GRID NEDO SINCRO.GRID SIREN SWARMGRID

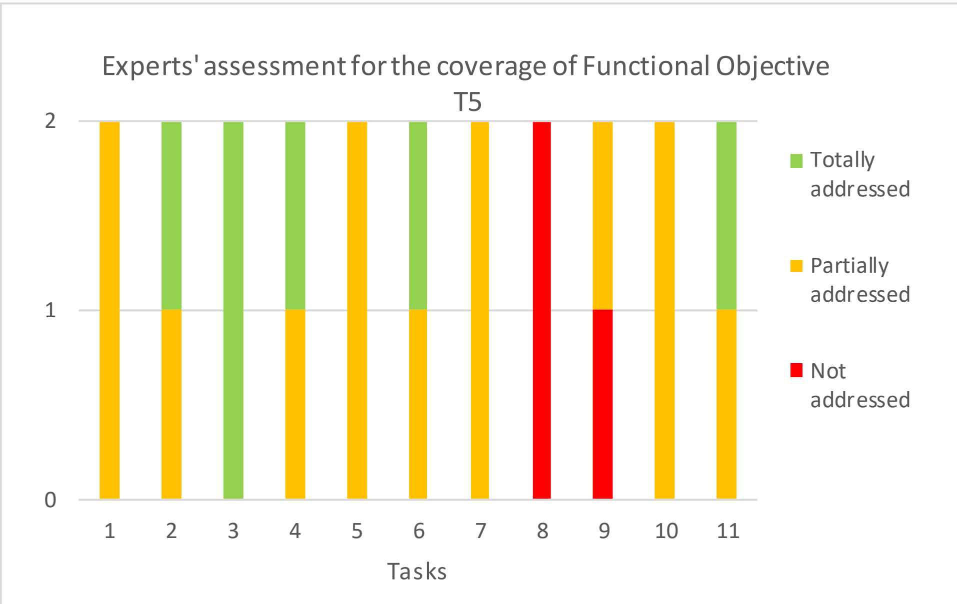
List of experts consulted

The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective T5.

Organisation	Name
IPTO	Christos Dikaiakos
VTT	Seppo Hänninen

Overview of the coverage of the Functional Objective according to experts' views

Among the eleven tasks covered in this functional objective, only one has been considered unanimously as not addressed (**task 8**), and another as partially or not addressed (**task 9**). Four tasks have been judged as partially addressed by all the experts (**tasks 1, 5, 7** and **10**). Four others received a partially or fully addressed assessment (**tasks 2, 4, 6** and **11**), and one has been assessed as totally covered by all the experts (**task 3**).



Overall achievements reached under this Functional Objective

eBADGE, SINCRO.GRID, SIREN, SUNSEED, SWARMGRID and NEDO projects reported to fully address **task 1**, covering essentially data processing equipment.

SUNSEED covered the **task 2** by developing tools based on monitoring electricity distribution grids. SINCRO.GRID tool used sensor data from both distribution and transmission grid.

eBADGE addressed the **task 3** through its development of a "market simulator". LIVING GRID project developed solutions related to the observability of the network, the advanced management of loads detachment, and monitoring and management of intentional island covering the local aspect of the task. OSMOSE project developed demonstrator of coordinated control of different storage and Flexible Alternating Current Transmission System (FACTS) devices.

Considering **task 4**, LIVING GRID project developed diverse solutions quoted in the previous paragraph, and they include observabilities on substation and local levels.

SUNSEED, SWARMGRID or INTERPLAN projects partially covered **task 5**.

Regarding **task 6**, GRIDSOL project has developed Dynamic Output Manager of Energy which operates forecasts of variable generation, flexible demand and innovative smart grid equipment such as sensors. LIVING GRID project has also developed grid observability & controllability.

NEDO addresses the **task 7** by testing an increased supply of tertiary frequency control with advanced services, increased supply of secondary reserves. In distribution grid, DSO notifies users about critical peak price 24 hours in advance. It covered data exchanges for different time frames from short-term to long-term.

Considering **task 10**, listed projects such as SINCRO.GRID or GRIDSOL, provided novel algorithms for processing large amount of data.

Regarding **task 11**, SIREN project developed and tested methods where transmission network control and protection system can be enhanced using synchrophasor measurement data. Wide Area Monitoring, Protection And Control (WAMPAC) systems incorporate three levels of protection functions: basic relay protection, central system protection with wide area protection functions (WAP) and power system control level. Centralized protection can use new methods based on synchrophasor data.

Main gaps to cover this functional objective

Considering **task 1**, projects still need to assess and validate the performance of intelligent local sensors.

Task 3 has been well covered by existing projects, no further research in the near feature seems to be mandatory.

Ongoing projects attempted to address the **task 5** but one of the key requirements (merge of transmission and distribution models) has not been enough analyzed. Projects must report how they developed observability by modelling grid and protection.

Exploitation of information could be clarified in the listed projects to check the coverage of **task 6**.

Regarding **task 7**, clarifications are requested on how project applied the data exchanges from real-time operational planning to network planning.

Aspects required for real time operation in **task 10** have not been covered by ongoing projects (e.g. for real time voltage control but not for other operations).

Futher studies could be useful to fully cover **task 11** even if topic is already well treated.

Proposal of evolution for the tasks

Tasks 1 and 2 could be merged between them.

Task 3 could be deleted as objectives have been reached.

Task 4 could be reformulated with simpler objectives.

Regarding **Task 5** several possibilities shall be considered:

- reformulate as "Increase observability and state estimation accuracy by accurate grid and protection modelling";
- reformulate to point out the importance of using merged models for the transmission and distribution networks;
- merge with **task 6**.

Task 6 could be merged with **task 5**.

Task 7 could be reformulated as "Enhance the TSO/DSO communication interface and design new architecture for data exchange at various system levels, and in different time frames".

Task 8 could be:

- reformulated as "Investigate and develop methodologies, procedures, protocols, standards and tools for inter-TSO communication and data exchange";
- merged with **task 9**.

Task 9 could be merged with **task 8**.

Task 10 could be merged with **task 11**.

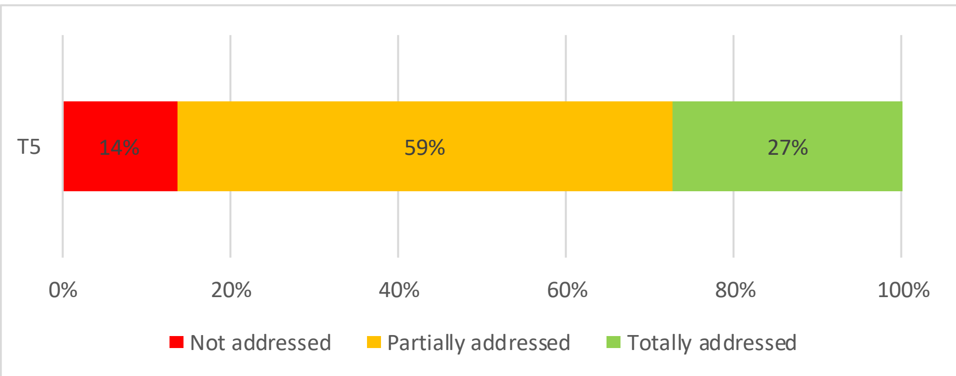
Task 11 could be:

- reformulated as "Implement solutions for WAMS and demonstrate how to utilize such information in a coordinated manner during operations also in critical situations";
- merged with **task 10**.

General conclusion for the coverage of the functional objective

- Few tasks have been considered as not addressed by the experts, due to a small coverage of their subjects in listed projects.
- A majority of tasks are partially or fully addressed thanks to the tools developed in EU projects.
- In terms of evolution for the tasks: eight tasks could be merged to form four new tasks; also some tasks could be rephrased to clarify their objective.

⇨ **Final coverage of the Functional objective:**



T6 – Grid controllability: frequency and voltage stability, power quality, synthetic inertia

List of tasks included in this functional objective

1. 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. Increase network controllability by proposing methods and tools for optimal and coordinated use of flexible equipment such as FACTS, PSTs and HVDC links, resulting in safe and cost-effective system operations (thus maximising the global social welfare)
3. Assess the contribution to controllability of large-scale new power technologies (incl. new materials) such as HVDC, VSC, superconductivity, energy storage, fault current limiters and other promising technologies for joint control of on- and off-shore networks, using fibre-optic temperature monitoring and DLR
4. Validate the contribution of RES to voltage and frequency control, as well as balancing, using different concepts, especially for direct-drive machines: VPP, inertia provided by the rotors, PE-based reactive power control, local storage, etc.
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) since these produce no harmonics pollution in the grid
6. Assess and demonstrate innovative solutions to counteract the decrease of short circuit current
7. Consider the large-scale intra-zone oscillation topic, assessing the deployment of the optimal infrastructure, the study and analysis of the data and the measurement of the impact of these intra-zone oscillations
8. Assess stability in grids with multiple control systems

List of projects considered

The following projects have participated in the survey and claimed to contribute to Functional Objective T6.

FP7/H2020 projects		**Other projects**	
EU-SysFlex FLEXITRANSTOR E GRIDSOL MIGRATE OSMOSE	PLAN4RES RealValue RESERVE SUNSEED	AMCOS HVDC LINK NEDO NEXUS Powerline Guardian/ Tower Router	SINCRO.GRID SIREN SMART GRID BATTERY STORAGE PROJECT PROTTES STENSEA

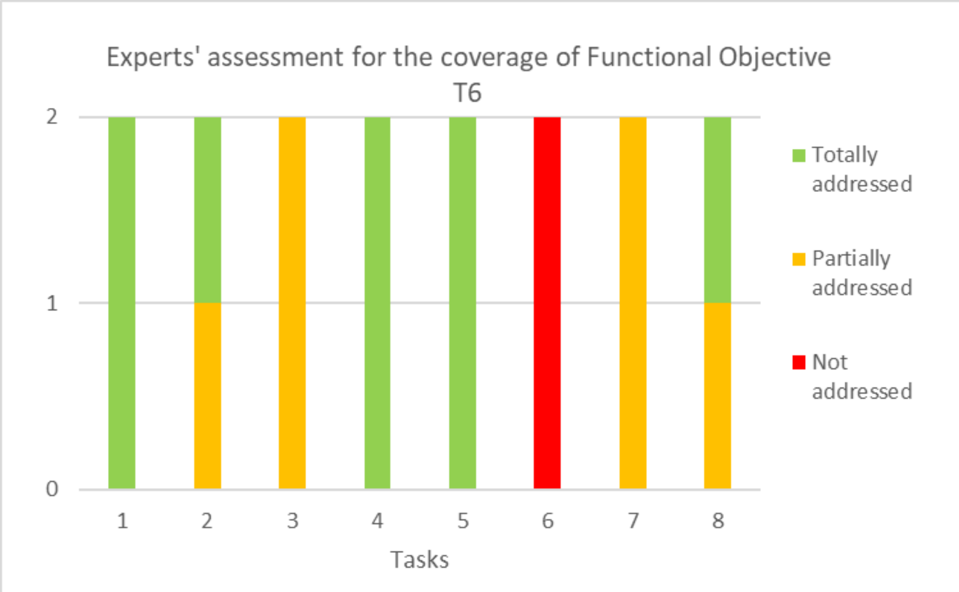
List of experts consulted

The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective T6.

Organisation	**Name**
IPTO	Christos Dikaiakos
VTT	Seppo Hänninen

Overview of the coverage of the Functional Objective according to experts' views

The tasks are considered either totally addressed (**tasks 1, 4, 5**), partially addressed (**tasks 3 and 7**), both partially and totally addressed (**tasks 2 and 8**). Only one task (**task 6**) is assessed as not addressed.



Overall achievements reached under this Functional Objective

Many projects demonstrate flexibility on the grid (power flow controllers), flexibility incorporating storage, flexibility in generation, in the border between TSO-DSO, etc. (**task 1**) such as OSMOSE, SINCRO.GRID and SIREN projects.

The FACT devices (**task 2**) are fully addressed by OSMOSE and HVDC LINK projects.

Regarding **task 3**, the projects are focusing mainly on control aspects (OSMOSE, NEDO, SIREN projects).

EU-SysFlex, GRIDSOL, MIGRATE and SIREN projects address the main concepts of **task 4**.

RESERVE, OSMOSE and SIREN projects cover the major parts of **task 5**.

The project SIREN developed the tool HOPS which automatically activate optimal amount of reserves in the case of grid disturbances. The tool exploits the data and measurements for activation of the reserves (**task 7**).

Regarding **task 8**, HVDC LINK project studies grid stability by applying HVDC control, OSMOSE project applies different FACTS devices. MIGRATE project covers tools for TSOs to be able to operate a stable grid system with nearly 100% RES.

Main gaps to cover this functional objective

Not all technologies mentioned in **task 3** are addressed. As example, no project covers new materials using fibre-optic temperature monitoring and DLR (Dynamic Line Ratings).

Additional project could report that their applications exploit the inertia provided by the rotors (**task 4**).

Further work on the application of VFT (Variable Frequency Transformer) could be developed (**task 5**).

Task 6 is not addressed at all by the projects.

Regarding **task 7**, further work is needed to study and analyze the data and the measurement of the impact of intra-zone oscillations in real time or afterwards.

Multiple control systems shall be further studied in line with **task 8.**

Proposal of evolution for the tasks

Task 2 could be either:

- merged with **task 3** since they include common topics: "Increase network controllability by proposing methods and tools 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 for joint control of on- and off-shore networks, using fibre-optic temperature monitoring and DL.";
- reformulated to focus mostly on the technical issues related to the stability of the system.

Task 3 shall be merged with **task 2** (see proposal above).

Task 6 could be:

- merged with **task 3;**
- or removed since it mainly covers the protection of the network and not directly response to the functional objective of grid controllability.

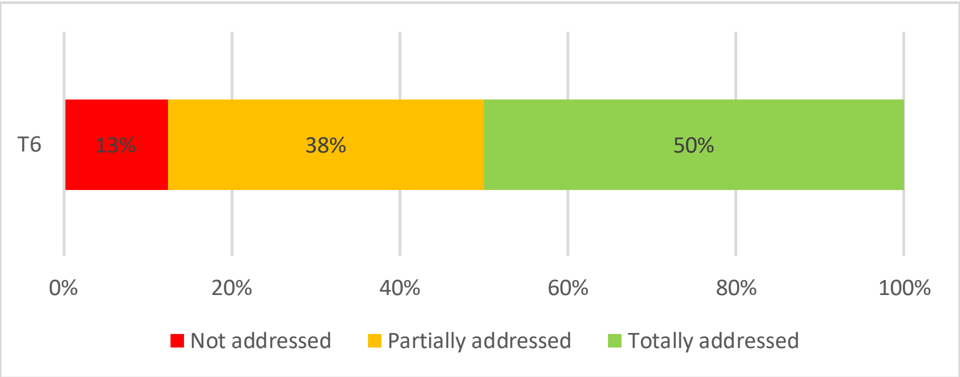
Task 7 could be:

- merged with **task 8** related to stability analysis;
- reformulated: "Investigation of the large-scale grid oscillation, the study and analysis of the data and the measurement of the impact of oscillations".

General conclusion for the coverage of the functional objective

- Three tasks are totally addressed (**tasks 1, 4, 5**);
- **Task 6** is not addressed at all by the projects;
- In terms of evolution for the tasks: a general simplification of the structure and merging of common topics is strongly recommended.

⇨ **Final coverage of the Functional objective:**



T7 – Expert systems and tools: expert systems, decision-making support tools and advanced automatic control

List of tasks included in this functional objective

1. Develop expert systems to assist in transient stability analyses of both voltage and frequency
2. Develop advanced decision support tools that integrate the probabilistic nature of variable generation in real time applications such as stochastic power flow, stochastic unit commitment, probabilistic reserve allocation, optimal power flow with RES forecasting, etc.
3. Assist with solving decision problems regarding reactive power and voltage control, determination of loads when applying load shedding schemes, etc.
4. 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.)
5. Develop tools for pan-EU system restoration based on coordination of Tie Lines and/or Black Start units, whilst taking into account the system condition, system constraints and available resources to support the decision
6. Combine sophisticated sensing technologies, automation and control methods with high-performance, high-speed communication infrastructure through the utilisation of multi-agent system architecture
7. Develop new methods that will reduce decision cycle time in decision-making analysis, especially in the case of increased variability, uncertainty of input data, and multiple conflicting evaluations
8. Develop and demonstrate innovative expert systems that take into account the uncertainties in the power system using artificial intelligence techniques and probability approaches such as Bayesian analysis
9. New control room environment must be developed to enable operators to handle complex decision-making situations (such an evolution could be compared to the aeronautical industry, in which there are automatic pilots and a fully digitalised environment). Specific trainings should also be adapted to the new ergonomic framework.

List of projects considered

The following projects have participated in the survey and claimed to contribute to Functional Objective T7.

FP7/H2020 projects	Other projects
GRIDSOL OSMOSE RESERVE	Advance Dispatching & LFOR SIREN

List of experts consulted

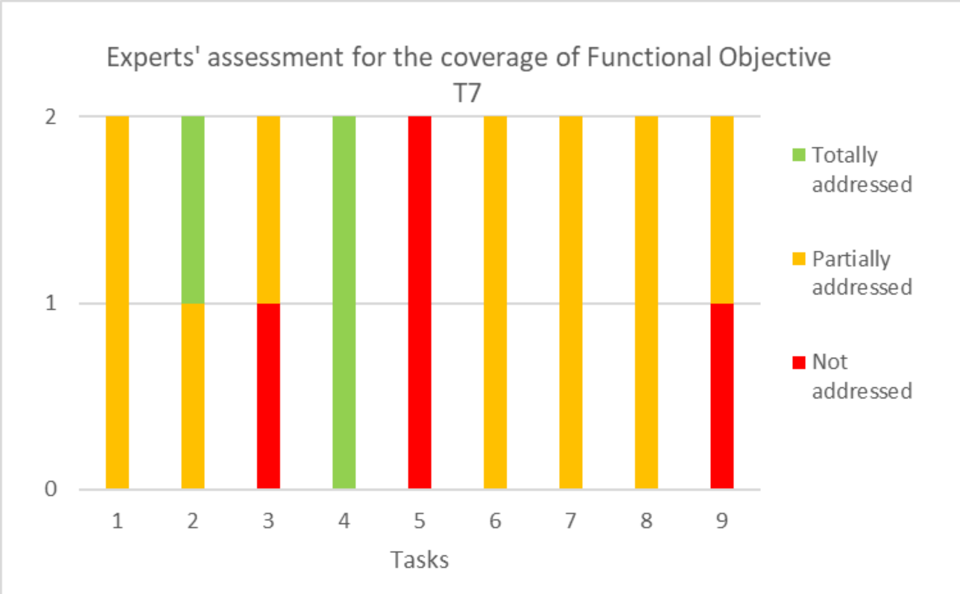
The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective T7.

Organisation	Name
IPTO	Christos Dikaiakos

VTT	Seppo Hänninen

Overview of the coverage of the Functional Objective according to experts' views

The tasks are considered either, unanimously partially addressed (**tasks 1, 6, 7, 8**), unanimously totally addressed (**task 4**), both totally and partially addressed (**task 2**) and both not and partially addressed (**tasks 3 and 9**). Only one task (**task 5**) is assessed as not addressed.



Overall achievements reached under this Functional Objective

RESERVE project studies new techniques for frequency and voltage management with up to 100% RES (in relation with **task 1**). SIREN project studies the services that storage can provide to the system.

ADVANCE DISPATCHING & LFOR project covers some aspects of **task 2**. The tool is developed to load forecasting and unit commitment.

Regarding **task 3**, ADVANCE DISPATCHING & LFORR project develops continuous real time load forecasting for adequacy assessment and optimal dispatching. The tool is not developed especially for case of load shedding, but it may provide good information of the forecasted loads in different areas of network which is beneficial for decision making of the areas where to apply load shedding actions.

GRIDSOL project covers some aspects of **task 4** with its Smart Renewable Hubs, where flexible power plants combined various generators (synchronous and non-synchronous) with energy storage to provide Hybrid RES dispatchable units, and the Dynamic Output Manager of Energy (DOME) which is the power plant controller of a Smart Renewable Hub (SRH). In addition, OSMOSE project addressed the topic through forecast reporting of optimal mix of flexibility, reporting of use of storages aggregating on the same device balancing needs, new and future system services (grid forming and frequency control) and congestion management. OSMOSE reported on flexibility solutions providing multiple services for use cases and on multiple services provided by grid devices, large demand-response and RES generation coordinated in a smart management system.

Regarding **task 6**, GRIDSOL project implemented innovative smart grid equipment such as sensors and controllers (based on ICT infrastructure) and the vision of a Virtual Power Plant

(VPP) and Virtual Storage Plant (VSP) aggregating distributed energy resources. RESERVE project developed high-speed communication for frequency and voltage control.

Advance Disptaching & LFOR-project covers **task 7** especially in the case of Optimized unit commitment of powerplants by applying advanced algorithms for linear programming, adopting mixed-integer variables (MILP) so as to optimize simultaneously the power generation mix, production profiles and the optimal configuration of each powerplant.

Regarding **task 8**, Advance Disptaching & LFOR project has developed continuous real time load forecasting for adequacy assessment and optimal dispatching. The project developed also tool for optimized unit commitment of powerplants applying advanced algorithms for linear programming, adopting mixed-integer variables (MILP). Based on other information, the load forecast and dipatching system apply: 1. Statistical models (e.g. time series AR, MA, ARMA), 2. Machine learning tools (e.g. Artificial neural network, Gradient Boosting Trees, custom Hybrid Models). The project apply also management of uncertainties.

Regarding **task 9**, the Advance Disptaching & LFOR project developed a real time application for the TSO's National Control Room, including: 1) Very short-term net-load forecasts powered by Load Forecast platform (Artificial Neural Networks algorithms, ANN), 2) Real time power-generating modules' adequacy assessment and remedial commitment proposals through optimization programming. These are the first steps to develop fully automated control room. The aim of the project was not to develop new control room environment and therefore the project covers automatic switching of line connectors (among others).

Main gaps to cover this functional objective

Regarding **task 1**, expert systems to assist in transient stability analyses shall be further developed within projects.

Concerning **task 2**, the reserve allocation and optimal power flow shall be further studied.

Task 5 is not addressed at all.

Regarding **task 6**, the multi-agent system architecture aspect shall be further developed.

Methods for fast desicion making in the case the grid suffers from severe stability problems shall be further developed to cover **task 7.**

Probabilistic approach such as Bayesian analyses **(task 8)** shall be further addressed.

Task 9 shall be further developped to focus on new control room environment.

Proposal of evolution for the tasks

Task 2 could be merged with **task 8** the following way: "Develop and demonstrate innovative expert systems for load and generation forecast, unit commitment, reserve allocation and optimal power flow taking into account uncertainties in the power system by applying artificial intelligence techniques and probability approaches."

Task 5 could include regions instead of the whole (European) system (difficult to study the Pan European system on a single project).

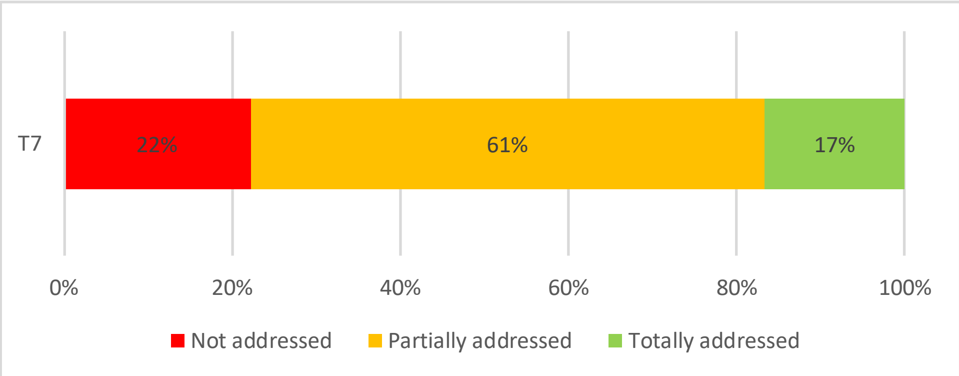
Task 6 could be:

- enlarged, so as not to be limited to the use of multi-agent architecture only;
- reformulated the following way: "Combine sophisticated sensing technologies, automation and control methods with high-performance and high-speed communication infrastructure".

General conclusion for the coverage of the functional objective

- Four tasks out of 9 are partially addressed, **Task 4** is totally addressed and **Task 5** is the only task considered as not addressed;
- In terms of evolution for the tasks, merge (**tasks 2 and 8**) or enlargement (**task 5 and 6**) of tasks shall be considered.

⇨ **Final coverage of the Functional objective:**



T8 – Reliability and resilience: defence and restoration plans, probabilistic approach, risk assessment, self-healing

List of tasks included in this functional objective

1. Address regulatory and technical challenges in the implementation of restoration plans at the pan-European level.
2. Include risk analysis in TSOs' daily business.
3. Identify specific resilience/vulnerability indicators.
4. Develop special tools for quantifying resilience.
5. Investigate the effects of extreme climate events as increasing threats to the transmission system of the future.
6. Evaluate the current performance of the (N-1) criteria security principles and the required level of reliability from the customer's perspective. Provide an appropriate approach for risk assessment based on probabilistic analyses of both normal and abnormal operations, taking into account correlations in the power system.
7. Evaluate new stochastic models with respect to market operations on different timescales in order to improve reliability.
8. Use a system approach to identify possible options for replacing (or complementing) the current reliability principles for different aspects of TSOs' business: grid development, markets, etc.
9. Define the additional information to be exchanged and the additional coordination needed to support deployment. Ensure effective and sufficient security margins during operation and operational planning.
10. Develop indicators for the evaluated criteria to help network operators make decisions for preventive and curative actions.
11. Develop simulation tools and methods for assessing the risk of breakdowns during reconnection.
12. Develop simulation tools and methods that detect weaknesses in the system with respect to reconnecting DER and storage systems.
13. Develop simulation tools for interactive system restoration, including advanced forecast tools for wind, solar PV and other variable RES. Assess the system state during the restoration process, and expected RES in-feed of DSO at reconnection.
14. Engage storage in defense and restoration tools and plans.
15. Investigate the contribution of DER to system restoration and immediate power reserves; this is relevant from the TSO perspective (e.g., black start capability and coordination of wind turbine generators). This will be assessed considering efficiency and cost-effectiveness when compared to the traditional or usual black-start approach.
16. Investigate the impact of micro-grids and islanding capabilities, taking into account efficiency and cost-effectiveness.
17. Train the system operators regarding the evolution of national regulatory schemes in order to foster coordination efforts.
18. Account for failure modes of ICT (including sensors) in the different simulation tools.
19. To develop effective and coordinated restoration plans specifically for ICT and software systems, in order to keep running the grid operation in case of natural catastrophes, terrorism and cyber-attacks.

List of projects considered

The following projects have participated in the survey and claimed to contribute to Functional Objective T8.

FP7/H2020 projects	Other projects	
RESERVE	LIVING GRID NEDO NEXUS	SIREN UNDERGROUND SUN STORAGE

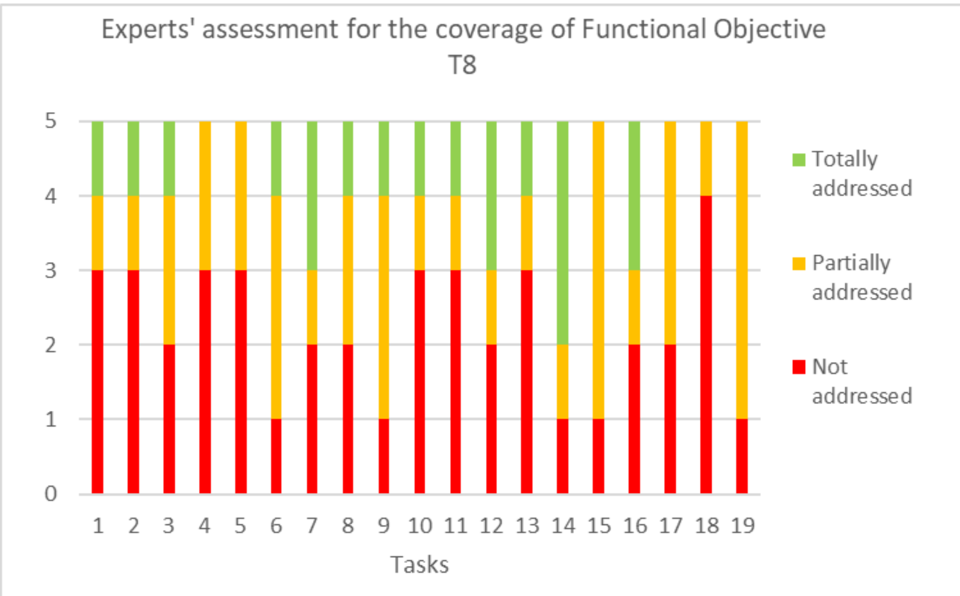
List of experts consulted

The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective T8.

Organisation	Name
IPTO	Christos Dikaiakos
Sintef	Andrei Z. Morch
TRACTEBEL	Steven De Boeck
VTT	Seppo Hänninen
GNF	Adoración Molina San Nicolas

Overview of the coverage of the Functional Objective according to experts' views

The tasks are considered either as not addressed or partially addressed (**tasks 4, 5, 15, 17, 18**). All the other tasks (**Tasks 1, 2, 3, 6, 7, 8, 9, 10, 11, 12, 13, 14** and **16**) are subjected to different assessments (not addressed, partially addressed and totally addressed).



PLAN. INNOVATE. ENGAGE.

Indeed, one of the experts considered only the aspects of the Natural Gas Grid Sector, and the UNDERGROUND SUN STORAGE project for his assessment. From this angle, none of the tasks were considered covered or relevant.

Overall achievements reached under this Functional Objective

Methodologies and software to improve the system monitoring, load management and management of islands has been developed and tested (**task 1**) by at least one project (LIVING GRID).

Concerning **task 2** the ongoing projects (such as LIVING Grid) are experimenting with solutions related to the observability of the network, management of load detatchment and monitoring and management of islanding which can reduce the operational risks.

Regarding **task 3**, the listed projects (LIVING GRID, NEXUS and SIREN) work with resilience and vulnerability indicators related to grid observability and controllability, as well as new operating procedures.

Regarding **task 4,** ongoing projects are developing tools adressing utilisation of DER and flexibility in system restoration, and thereby quantifying resilience.

Considering **task 6**, the N-1 criteria has been considered from a generation-load balance perspective in at least 2 projects: LIVING GRID, SIREN.

Regarding **task 7**, models have been defined for wind and storage on different time scales in at least one Project (SIREN).

Regarding **task 8,** the SIREN project has used system approach by developing and including storage as an option for the expansion of a transmission network. The considered storage technologies include both conventional storage units, e.g. pumped hydro storage power plants and compressed air energy storage (CAES), and large-scale batteries and flywheel. This complements the current reliability principles.

Concerning **task 9,** LIVING Grid project studies new observalities and network management. SIREN developed new operating procedures for HOPS which is operating the power system in real time and the new Investment Strategies. These projects define additional information to be exchanged and additional coordination strategies.

At least 2 projects (SIREN and LIVING GRID) focus on operational aspects such as monitoring and control (**task 10**).

Regarding **task 11,** at least SIREN and LIVING Grid have developed tools within the scope of their project, i.e. for RES integration and islanding.

Regarding **task 12,** the projects SIREN and LIVING GRID developed simulation tools for storage and DER grid integration.

Regarding **task 13,** the Project LIVING GRID developed solutions related to the observability of the network, the advanced management of loads detachment, and monitoring and management of intentional island**.**

Regarding **Task 14**, at least 3 projects (LIVING GIRD, NEDO, SIREN) analyse methods to overcome incidents with storage. More precisely, the project LIVING GRID and SIREN develop tools for grid integration of storages and DER and grid operation.

Considering **task 15**, at least 3 projects (LIVING GRID, NEXUS, NEDO) cover to certain extent the part of the task regarding to investigate the contribution of DER to immediate power reserves of the system.

Considering **task 16,** within the Projects (LIVING GRID, NEXUS, NEDO), the technical aspects of the tasks are analysed.

Considering **task 17**, the projects (LIVING GRID and NEDO) study the regulatory aspects from different views and the evolution of national regulatory schemes

Considering **task 19,** the RESERVE project studies the new features of 5G mobile communications that could offer local processing and the support of mobile communications in the event of power grid failure

Main gaps to cover this functional objective

Further testing is required concerning the pan-European aspect as well as further investigation of regulatory challenges regarding **task 1.**

Regarding **task 2**, further demonstration of generic inclusion of risk analysis in TSOs' daily business is needed.

Concerning **task 3**, further development of a holistic approach to address the identification of resilience/vulnerability and specific indicators is required.

Regarding **task 4**, further development of tools for quantification of resilience with a holistic approach is required.

Regarding **task 5**, extreme climate events are not addressed directly by the projects.

Regarding **task 6,** broader work on defining an approach for risk assessment based on probabilistic analyses of both normal and abnormal operations, taking into account correlations in the power system shall be considered.

Regarding **task 7**, broader work on evaluation of new stochastic models with respect to market operations on different timescales in order to improve reliability shall be addressed.

Regarding **task 8,** the Grid development has not been sufficiently addressed and no broad work is found on options for replacing (or complementing) the current reliability principles.

Regarding **task 9**, more demonstration related to the latter part of the task “Ensure effective and sufficient security margins during operation and operational planning" shall be developed.

Regarding **task 10**, broader work on developing indicators for the evaluated criteria to help network operators make decisions for preventive and curative actions shall be considered.

Regarding **task 11**, the overall goal of the task is not reached to develop simulation tools and methods for assessing the risk of breakdowns during reconnection.

Regarding **task 12**, a focus on reconnection issue could be further developed

Regarding **task 13**, Foster the study of a full reconstruction of the system

Regarding **task 14**, activities around system restoration shall be fostered.

Regarding **task 15**, work on system restoration including black start could be further developed. Moreover, it is suggested to further analyse the contribution of DER for black start and restoration and compare the cost with classical black start providers.

Considering **task 16,** the analysis of the cost effectiveness could be made clearer.

Considering **task 17**, specific work on training the system operators regarding the evolution of national regulatory schemes in order to foster coordination efforts shall be further addressed.

Considering **task 19,** activities related to effective and coordinated restoration plans specifically for ICT and software systems in the case of natural catastrophes, terrorism and cyber-attacks shall be further developed.

From the Natural gas grid point of view, none of the tasks are covered. Further activities shall be developed to address the different topics (when relevant for the sector).

Proposal of evolution for the tasks

Task 1 shall focus more on the regulatory changes needed for an implementation at the Pan-European level.

Task 2 could be:

- reformulated to consider not only risk analysis of TSO but also DSO and specify the part (s) of risks to be considered (risk of defence and restoration plans failing, risk of extraordinary events, risk of lost load, financial risk, ...)
- merged with task 3 related to resilience indicators.

Task 3 could be reformulated and merged with **task 10** to have only one task related to indicators: “Develop indicators for resiliance/vulnerability and based other criteria to help network operators make decisions for preventive and curative actions.” More specification about the purpose of the indicators shall be indicated (the long term/short term planning, Grid operation, Outage scheduling, All system operator tasks, etc).

Task 4 could be:

- reformulated to include specific methodologies to quantify the resiliency towards different types of contingencies and variabilities;
- reformulated the following way:” Develop special tools for quantifying grid resilience”;
- Or merged with the previous task to have only one task related to indicators.

Task 5 could be:

- merged with **task 6** to have the same topic within one task (risk assessment);
- or a new task could be addressed: “Investigate the geospatial sizing of assets (storage, conventional units, etc.) taking into account the availability of grid assests in order to withstand the impact of extreme wheather events.”;
- Two experts consider that the task should not be modified.

Task 6 could be:

- reformulated the task and include also the analysis of the grid side towards new security criteria;
- divided:
    - evaluate the current performance of the (N-1) criteria security principles and the required level of reliability from the customer’s perspective;
    - develop tools for risk assessment based on probabilistic analyses of both normal and abnormal operations, considering correlations in the power system.

Task 8 could be combined with **task 7**.

Task 9 could focus on the second part of the task “Ensure effective and sufficient security margins during operation and operational planning”.

Task 10: see proposal for **task 3.**

Task 11 could be merged with **task 12**.

Task 12: see **task 11**. The task could be more generic and not only with regards to “reconnection of DER and storage”.

Task 13 shall be simplified with clearer target.

Task 14 could be merged with **task 15**.

Task 15 could be merged with **task 14** with a focus on black start.

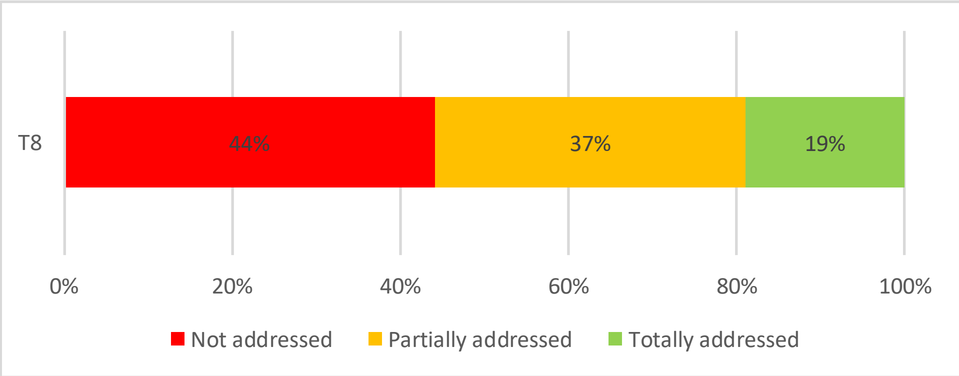
Task 17 could be more generic such as “the evolution of national regulatory schemes in order to foster coordination efforts”.

Tasks 7, Task 18 and **task 19** shall be kept as they are.

General conclusion for the coverage of the functional objective

- The following tasks are partly covered by the projects identified with tangible examples: **Tasks 3, 6, 7,8, 9, 12, 14, 15, 16, 17,19;**
- The main gaps are clearly identified (see above section): pan European dimension to be fostered, study of extreme climate events to be further developed, consideration of the restoration of the system after a failure, training of operators, etc.
- In terms of evolution for the tasks: a general simplification of the structure and merging of common topics is strongly recommended

⇨ **Final coverage of the Functional objective:**



T9 - Enhanced ancillary services for network operation

List of tasks included in this functional objective

1. Increase the visibility of variable RES for TSOs (to enable more accurate forecasting)
2. Perform dynamic calculations of RES production using short-term forecasting models or by continuous updating of the data
3. Develop new common security provisions that enable the definition of a reliable and efficient amount of reserves and the sharing of these reserves based on acceptable and measurable risk (cf. to project GARPUR)
4. Assessing processes, principles, and strategies for new ancillary services to manage the high penetration of RES and balancing demand (faster ramping services, frequency response, inertia response, reactive power, and voltage control)
5. Determine novel ways of providing ancillary services through loads and their impact on transmission networks; the highly variable and unpredictable nature of DER and RES places new constraints on these ancillary services
6. Determine novel ways of providing ancillary services through storage systems, and their impact on transmission networks
7. Develop simulation environments to test the viability and options of ancillary service provision by aggregated loads at the DSO level
8. Technologies and tools for active and reactive power control of DER, with TSO/DSO coordination to provide extra power flow control, load management and islanding.
9. Create robust optimisation algorithms for coordinated control of DER (robust against uncertainties and variability)
10. Introduce new actors and market models that enable DER and storage to provide ancillary services.
11. Develop new models that describe products and services to be tested on selected segments of customers, and determine their impact on future ancillary services in the presence of large-scale DER integration
12. Create new market models that account for the price-sensitive nature of loads and their resulting flexibility
13. Analyse the legal, contractual and regulatory aspects of ancillary services provided by distributed generation and / or loads, allowing for more aggregated business models
14. Share best practices between TSOs and DSOs for the ancillary services provided by units connected at distribution networks

List of projects considered

The following projects have participated in the survey and claimed to contribute to Functional Objective T9.

FP7/H2020 projects		Other projects	
EU-SysFlex FLEXITRANSTORE FutureFlow GRIDSOL MIGRATE	OSMOSE RealValue RESERVE SMARTNET	Advance Disptaching & LFOR CLOUDGRID DS3 Hybridised LAES LIVING GRID NEDO	NEXUS Power Off and Save SIREN STENSEA SWARMGRID UNDERGROUND SUN STORAGE

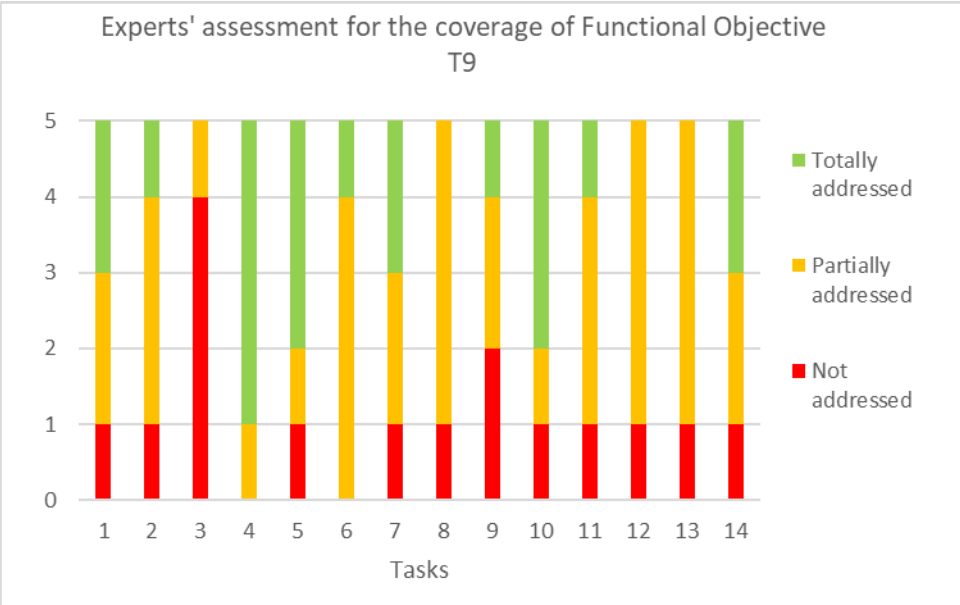
List of experts consulted

The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective T9.

Organisation	Name
VTT	Seppo Hänninen
VITO	Helena Gerard
CENER	Monica Aguado
GNF	Adoración Molina San Nicolas
IPTO	Christos Dikaiakos

Overview of the coverage of the Functional Objective according to experts' views

The tasks are considered either not addressed or partially addressed (**tasks 3, 8, 12** and **13**). **Tasks 4** and **6** are considered partially or totally addressed. The other tasks (**Tasks 1, 2, 5, 7, 8, 9, 10, 11** and **14**) are subjected to different assessments. Indeed, one of the experts considered only the aspects of the Natural Gas Grid Sector, and the UNDERGROUND SUN STORAGE project for his assessment. From this angle, most of the tasks were considered not addressed or not relevant for the sector.



Overall achievements reached under this Functional Objective

The Advance Disptaching & LFOR project mainly cover **task 1**: the tool (Advance Dispatching and real time load forecast, LFOR Platform) could be applicable, with high performances, both for the active power net load forecast. FutureFlow project studies the secondary reserve markets. Moreover, some projects test the observability of RES in small-scale pilots (such as. SMARTNET).

At least, one project (DS3) provides a real-time assessment of the transient and voltage stability of the power system, allowing Grid Controllers to take appropriate actions with the Wind Security Assessment Tool (WSAT) within **task 2.**

Regarding **task 4**, several projects explicitly focus on the development of new system services (e.g. EU-SysFlex, DS3, MIGRATE, GRIDSOL, RESERVE, SIREN). Several projects also demonstrate the proposed new ancillary services and elaborate on proccesses and principles to procure and activate these new ancillary services. In addition, taken into account the size of the projects having this task as their “core mission”, sufficient steps will be taken to consider this task as covered when these projects are finalised (e.g. some of them such as EU-SysFlex only started end of 2017).

Ongoing projects (CLOUDGRID, EU-SysFlex, FLEXITRANSTORE, GRIDSOL, etc) propose novel ways of providing ancillary services through Demand Side Management and also analyze the impact on transmission networks within **task 5.**

Some projects (SMARTNET, SIREN, UNDERGROUND SUN STORAGE, NEDO, etc.) have demonstrated the use of storage in the provision of specific Ancillary Services – AS - (**task 6**) within a specific market framework.

Some projects (DS3, SMARTNET, etc.) have developed simulation environments to test several scenarios for the provision of specific AS (**task 7**).

Regarding **task 8**, FLEXITRANSTORE (Key Exploitable Result 5) developed efficient solution based on controllers and battery storage situated at the TSO-DSO border to provide flexibility services. LIVING GRID project tested solutions related to the observability of the network, the advanced management of loads detachment, and monitoring and management of intentional island. GRIDSOL has addressed the interaction between TSOs and DSOs, including the provision of Ancillary Services at the TSO/DSO interconnection point more concretely by developing software for a specific service within a specific market context.

Concerning **task 9**, advance Disptaching & LFOR-project developed advanced algorithms to optimize simultaneously the power generation mix, production profiles and the optimal configuration of each powerplant.

CLOUDGRID, DS3, EU-SysFlex, GRIDSOL, NEDO, RESERVE, SWARMGRID, SMARTNET projects focus on the development of new actors and market models and demonstrate solutions in the framework of these new market models (**task 10**). The output of the different projects provides both conceptual frameworks and qualitative and quantitative assessments of the concepts.

A first set of models related to products and services that could be used for future ancillary services in the presence of large scale DER (**task 11**) is presented, for example by EU-SysFlex, GRIDSOL, LIVING GRID, NEDO, RESERVE, SMARTNET and SWARMGRID.

Regarding **Task 12**, NEDO tested small grid users (households, small business) in ancillary services. SMARTNET developed testing facility for AS provision from thermostatically controlled loads.

Most of the projects (DS3, GRIDSOL, etc.) that developed new products, services, market concepts or business models have made a regulatory assessment of the solutions proposed in their individual Project (**task 13**).

Main gaps to cover this functional objective

Regarding **Task 1** smart algorithms aspects to support the large-scale realisation of increased real-time observability shall be further addressed. The impact of increased observability on innovations in grid planning and operation, including new models for market design are not yet sufficiently explored.

In line with **Task 2**, the development of dynamic calculation considering short forecasting shall be fostered. Further extensions of WSAT may include assessment of frequency stability

Regarding **Task 5**, more work could be done to develop innovative algorithms that should take into account the 'non-rationality' of load (currently not addressed by most projects). The interaction with other providers of AS (e.g. storage) could be further elaborated upon. New decentralised market concepts for AS (including the emergence of local energy communities) might also require a further deepening of the role of 'loads' in the provision of AS.

Concerning **Task 6**, most projects did not pay specific attention to the role of storage in the provision of AS, in particular the link between storage and other providers of AS (e.g. load, distributed generation, etc.) is not detailed. The link with other carriers (gas, heat) and the role of storage in a multi-carrier context is not fully explored. In this perspective, the role of local energy communities will become more important as well.

For projects that developed a simulation environment **(Task 7)**, the environment was bounded by specific AS or by specific scenarios for a limited set of countries. Further work to go beyond those limitations are needed.

Further results related to reactive power control and islanding are expected (**Task 8**). Additional tools shall be developed (see Proposal of evolution for the tasks).

Regarding **Task 9** optimization algorithms for coordinated control of DER shall be further developed.

The aspect of cross-border integration, the participation of load, the interaction between stakeholders are not always addressed (**Task 10**). More research could be done related to innovative market set-ups (e.g. peer-to-peer markets for AS, markets for both regulated and non regulated players, new roles for TSOs and DSOs, etc). It could be interesting to assess the different market concepts in the context of new services for the system.

Attention should be given how the new products and services proposed by the projects can be integrated in different market environments (in line with **Task 11**). Topics such as aggregation, smart bidding strategies, market clearing, etc.) will have to be considered.

Smart aggregation strategies of loads of innovative control algoritms taking into account the price sensitivity of load shall be further focus on regarding **Task 12**. In addition, aspects such as irrational behaviour that could influence the reaction of load to proce signals shall be further explored.

Concerning **Task 13** overall assessment of the different regulatory barriers in the context of emerging business models shall be further developed. Most projects emphasize the general regulatory framework (both EU and national level), but the individual legal or contractual arrangements are not assessed in detail.

Regarding **Task 14** knowledge sharing is achieved indirectly by having multiple TSOs and DSOs present in the consortium (e.g. EU-SysFlex, SMARTNET, NEDO, etc.).

From the Natural gas grid point of view: most of the tasks are considered as not addressed or not relevant for the sector. Only 2 tasks (Tasks 4 and 6) are considered as partially addressed. One Project represents an important element to demonstrate that H2 can be added to the NG system and thus provide long-term storage for excess RES.

Proposal of evolution for the tasks

Task 1 could be merged with **task 2**. It will be important that, attention is given to smart algorithms and tools that allow a better observability of RES in real-time (including an update of the procured and activated reserves) and a better forecast of RES production on the other hand to be used for operational planning purposes. In case the task would be kept separately, reformulation is needed to focus on the fact that observability happens in real-time.

Task 2 could be merged with **task 1**.

Task 3 could be:

- more specific using scenarios with regards to RES penetration, etc;
- included in a unique package with the first three tasks;
- complemented by adding explicitly to the definition is the link with cross-border markets and the changes in the design of markets for ancillary services (including joint procurement of reserves, sharing of reserves).

Task 4 could be removed (totally covered). New challenges could be incorporated to see which new concepts of market design are necessary to allow more technologies/stakeholders to participate to these new ancillary services.

Task 5 could be merged with **task 6**. In particular, it will be important to assess the interaction of several types of AS providers (storage, load, decentralised generation, RES, etc.) in the process of providing AS. In particular, the possible role of local energy communities (including services, processes and possible regulatory barriers) should be addressed in this context.

Task 6 could be merged with **task 5** or reformulated the following way:

- consider the simulation of storage on a larger scale and take into consideration the cross-border mechanisms to cover more the impacts on the transmission networks, OR
- combine with tasks related to ancillary services.

Task 7 shall be kept as it will be important that advanced simulation environments are developed that can test several options for market design, AS procurement, TSO/DSO interaction processes in an integrated way, for several countries and for several scenarios. However, in the new task, it will be important to widen the scope and have a simulation environment which is not only looking at aggregated loads but also at other sources of flexibility. In addition, aspects such as cross-border, interaction with other AS markets and different options for market design should be able to be integrated in the simulation environment. In addition, it might be an added value if different aggregation strategies could also be tested in the simulation environment.

Task 8 shall be reformulated in a new task. The aspect of tool development should be enlarged, starting from different set-ups of coordination between TSOs and DSOs. Dependent on the TSO-DSO coordination scheme and the resulting market design, specific tools will be needed. Moreover, the link with the physical grid constraints is important to consider.

Task 9 could be merged with **task 8.** The coordinated control shall be extended to VPP and SPP.

Tasks 10 and **11** could be merged**.**

Task 12 should be enlarged, considering also aspects such as smart aggregation algoritms and irrationality as topics to take into account the price sensitivity of load.

Task 13 could be reformulated, focussing more on the individual cases.

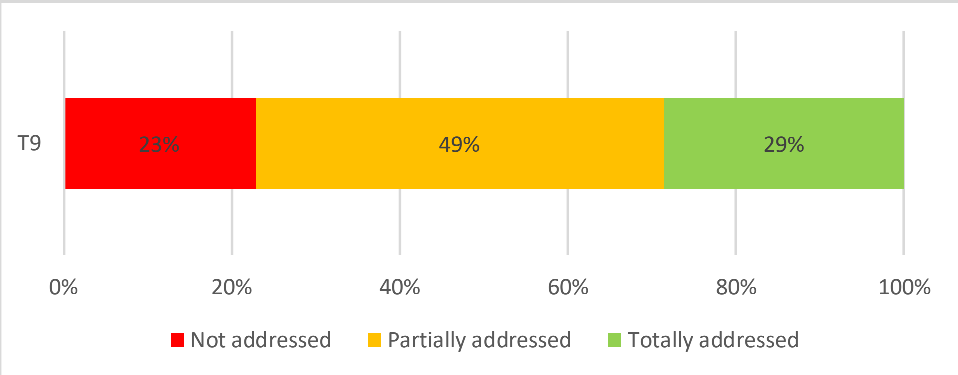
Task 14 shall focus on processes, tools and technologies that support the increased interaction between TSOs and DSOs. To be merged with task 8 to foster knowledge sharing.

Regarding the Natural gas grid point of view, other projects will be required to fill in the current knowledge gaps for the addition of H2 in the NG system. Work is required on the compatibility of end-user appliances, both domestic and industrial with H2 admixtures.

General conclusion for the coverage of the functional objective

- On a whole, not considering the natural gas grid point of view, homogenous assessment from the different experts;
- Tangible example available for the tasks assessed as totally addressed by some experts: **Tasks 1, 2, 4, 5, 6, 7, 10, 11, 14**;
- In terms of evolution for the tasks: a general simplification of the structure and merging of common topics is strongly recommended

⇨ **Final coverage of the Functional objective:**



CLUSTER 3 – POWER SYSTEM FLEXIBILITY FROM GENERATION, STORAGE, DEMAND AND NETWORK

T10 - Storage integration, use of storage services

List of tasks included in this functional objective

1. Power-to-power cycles with optimal efficiency and minor losses; integration with other energy systems that can regenerate losses, e.g., heat
2. Novel solutions for fast power response and energy storage at different voltage levels in the power system; novel solutions for where supplementary services will be located in the storage facility
3. System planning tools to determine the optimal distribution of the energy storage to facilitate transmission system operations, as well as in the distribution grids
4. Defining technical requirements/specifications to allow storage integration to provide system services.
5. Simulation tools to better appraise the cycling profiles associated with the envisaged applications and business models. This will, in turn, allow an accurate estimation of the lifespan of the storage system (and the failure modes) and profitability
6. Improvement of current system modelling tools to better account for the benefits of storage and to optimise the balancing; measuring the impacts of OPEX and CAPEX using stochastic modelling
7. Tools to assess potential revenues from storage, in both liquid markets and non-liquid markets
8. Assess the contribution of power-to-gas technologies as a means to store electricity on large scale; use of gas turbines to cover long periods with low RES generation in scenarios with very high penetration of wind and solar generation
9. Increase the integration of storage in thermal power plants in order to improve their flexibility
10. Develop methodologies to integrate new bulk storage solutions (e.g., power-to-gas, marine storage, CAES).
11. Asses the value of hybrid technology projects, for example mixing technologies able to perform a high number of cycles with other less CAPEX intensive technologies
12. Assess and quantify the value for the system of services provided by energy storage

List of projects considered

The following projects have participated in the survey and claimed to contribute to Functional Objective T10.

FP7/H2020 projects	Other projects	
FLEXITRANSTORE GRIDSOL **H2FUTURE** **INTERPLAN** **OSMOSE** **PLAN4RES** **RealValue** **TILOS**	ADELE ADOSA ALISIOS AMCOS CEDREN HydroBalance CLOUDGRID Hybridised LAES KRYOLENS LIFE ZAESS	Schwungrad Rhode Hybrid Test Facility SIREN SMART GRID BATTERY STORAGE PROJECT PROTTES STENSEA STORAGE LAB

FP7/H2020 projects	**Other projects**	
	NEDO NEXUS	UNDERGROUND SUN STORAGE

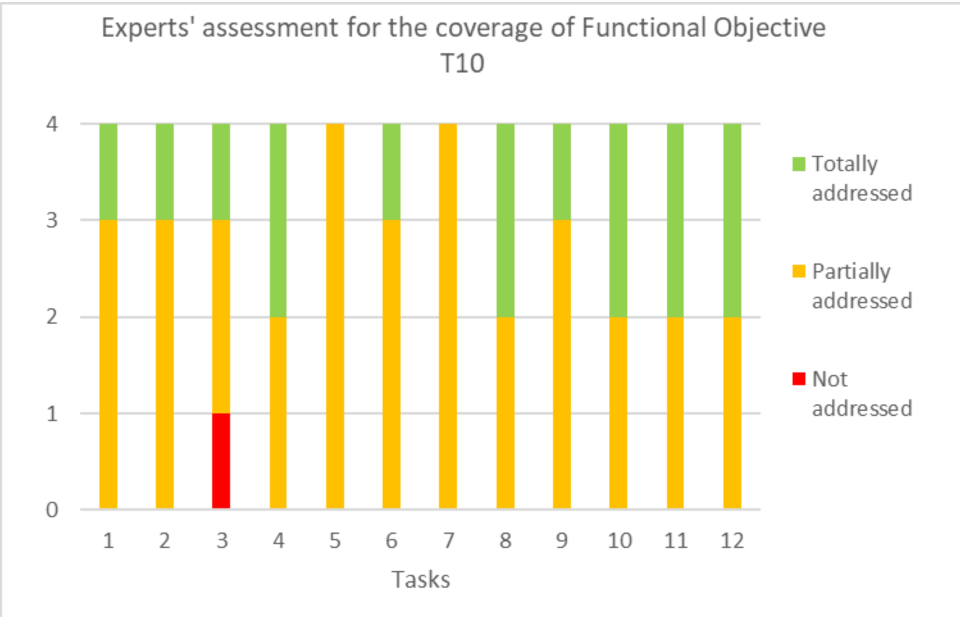
List of experts consulted

The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective T10.

Organisation	**Name**
REE	Miguel Lorenzo Sotelo
VITO	Grietus Mulder
VTT	Seppo Hänninen
CENER	Raquel Garde

Overview of the coverage of the Functional Objective according to experts' views

The tasks are considered either both partially and totally addressed (**tasks 1, 2, 4, 6, 8, 9, 10, 11, 12**) or unanimously partially addressed (**tasks 5 and 7**). Only one task (**task 3**) presents aspects not addressed, partially and totally addressed.



Overall achievements reached under this Functional Objective

Regarding **task 1**, at least two projects study power-to-power cycles using compressed air and Liquid Air Energy Storage (ADELE and KRYLOENS).

The projects considered for **task 2** cover major part of the task including also slow power responses of storages. The storage types of the projects are not novel solutions (ACAES, flywheel, Liquid Air Energy Storage, different types conventional batteries) but their applications providing ancillary services are somehow new. More generally, new storage facilities (alone or by means of hybridation) can provide a wide range of system services. For most of them, Grid Codes provide a clear guideline while for new ones more join research must be done among grid operators and developers in order to characterize them and eventually standarization.

Regarding **task 3,** the KRYOLENS Project covers the transmission system aspect.

Many projects cover some aspects of the defining technical requirements/specifications to allow integration of different types of storages in order to provide system services (**task 4**) such as ALISIOS, FLEXITRANSTORE, GRIDSOL, H2FUTURE, KRYOLENS, SIREN, etc.

Some projects have developed simulation tools for appraise the cycling profiles and business models for different type of Energy storage systems (**task 5**) such as ADOSA, KRYOLENS, SIREN, STORAGE LAB and TILOS projects.

The ADOSA Project is addressing part of **task 6** with their tool accounting for OPEX, CAPEX, efficiencies, sources of revenues, lose or increase of revenues due to storage, etc.

Business models and economis aspects (**task 7**) have been studied by some projects (Hybridised LAES, Hydrobalance, etc.).

Two projects cover fully **task 8** to assess the contribution of power-to-gas technologies (H2FUTURE and UNDERGROUND SUN STORAGE projects). The latter has one result "Seasonal balancing (storage) of Renewable Energy", which covers also the requirement of long periods with low RES generation.

Some aspects of **task 9** are considered. For example, the KRYOLENS project is applying LAES storage.

Different types of energy vectors: power-to-gas, marine storage (underwater pumped hydro) and CAES are covered (STENSEA, Underground sun storage, KRYOLENS, H2FUTURE, ADELE) in relation with **task 10**.

Some aspects of **task 11** are addressed (Hybridised LAES, KRYOLENS). LAES hybrid Solutions combining LAES with thermal power plants are compared to LAES pure power-to-power Solutions.

The assesment and quantification of the value for different services provided by different types of energy storages (**task 12**) are covered by some projects (SIREN, TILOS, H2FUTURE, Hybridised LAES, NEDO).

Main gaps to cover this functional objective

Regarding **task 1**, the integration with other energy systems and other types of storages are not fully covered e.g. P2H and P2G and the efficiency in those cases.

Development of new solutions (hardware) or testing is hardly carried out in line with **task 2**. More join research must be done among grid operators and developers in order to characterize system services and eventually standardization.

The optimal distribution of storages in transmission and distribution system (**task 3**) shall be further studied.

The definition of technical requirements (**task 4**) shall be fully tested. Requirements depend on the grid characteristics (on countries), on the storage technology and have an impact in the national and european network codes that should be taken into account.

The accurate estimation of the lifespan of the storage system and also failure modes of storages (**task 5**) shall be further addressed and additional tools shall be developed.

Further work on stochastic modelling is needed for **task 6**. A consistent and robust methodology to assess benefits and costs of novel technologies (not only storage) is needed to provide some basis which eventually might be agreed and accepted by National Regulatory Authorities' in order to be used to support system planning activities.

Regarding **task 7**, further study on potential revenue in both liquid and non-liquid markets shall be made and additional tools to cover all types of storage technologies shall be developed. Markets depend on the country and local regulations, general tools easy tuneable would be useful.

Concerning **task 9**, more different types of storage technologies should be studied for integration in thermal power plants.

Regarding **task 12** results shall be broadly available and based on general scenarios (at the moment, dependent of the local situation).

Proposal of evolution for the tasks

Task 1 could be reformulated**:**

- as a new task: "Study cost-efficiency of each technology in connection to the different system services from a long run perspective as well as scalability and replicability potential";
- or the following way: "Power-to-power cycles and integration with other energy systems with optimal efficiency and minor losses" or "analysis of overall efficiency and synergies with other energy systems to enhance performance".

Task 2 could be:

- merged with **task 4**: "Research on the characterization and, to same extent, standarization of new services that can be provided by storage facilities (e.g. synthetic inertia)";
- reformulated the following way:
  - "Novel solutions for fast and slow power response and ansillary services provided by energy storage at different voltage levels in the power system";
  - or "Analysis and development of novel solutions including energy storage for fast power response and ancillary services support".

Task 3 shall be addressed not only from an academic or technology-focused viewpoint but in close cooperation with regulatory bodies in order to ensure propper alignment with them. Another proposal is to reformulate the task the following way: "System planning tools to determine the optimal distribution of the energy storage in power system."

Tasks 2 and 4 could be merged (see above proposal). **Task 4** could be also reformulated to include the network codes aspects "Analysis of technical requirements for energy storage integration and grid services provision. Definition of harmonised network codes (or recommendations) considering ESS functionalities".

Task 5 could be:

- merged with **task 3, task 6 or task 12;**
- reformulated the following way: "simulation tools to better appraise the cycling profiles associated with the envisaged applications and business models. The mathematical fundamentals including ageing must be open. This will, in turn, allow an accurate estimation of the lifespan of the storage system (and the failure modes) and profitability."

Task 6 could be:

- merged with **task 3;**
- merged with **task 5** the following way: "Development of open source tools for selection and sizing of energy storage systems (also hybrid technologies) according to the applications (or services to provide) and their characteristics (CAPEX, OPEX, cycling, lifetime, efficiency, etc.) in order to design cost-effective projects including energy storage";
- reformulated to leave out the "stochastic modelling" aspect.

Task 7 could be reformulated to consider results in other tasks addresssing common aspects points. The tools could also consider delivering multiple services, adaptable to the countries and markets and covering from short to long term markets. Another option would be to merge the task with **task 12** "Assess and quantify the value for the system of services provided by energy storage".

Task 8 could be:

- reformulated to create a new task to strengthen the detail assessment of the potential of each solution for integration with different kind of energy-intensive industries (such as H2FUTURE project with steel production);
- merged with **task 10** and reformulated the following way: “Develop tools and/or methodologies to assess (quantify added value) the potential of bulk energy storage (P2G, CAES, LAES, etc.) to increase RES share in the long term and large scale”.

Task 9 could be:

- reformulated to focus on evaluating the most efficient way to integrate storage in order to provide more flexibility from a system perspective (integration with individual power plants is only a partial solution);
- complemented by a new task entitled “Develop tools to assess (quantify) the benefits of using energy storage associated to thermal power plants”.

Task 10 could be clarified and merged with other tasks addressing similar topics (**task 4** or **task 8** as example).

Task 11 could be merged with tasks of common topics such as **task 12** or linked with **task 5 and 6.** A task focusing only on “hybrid" technologies could also be proposed.

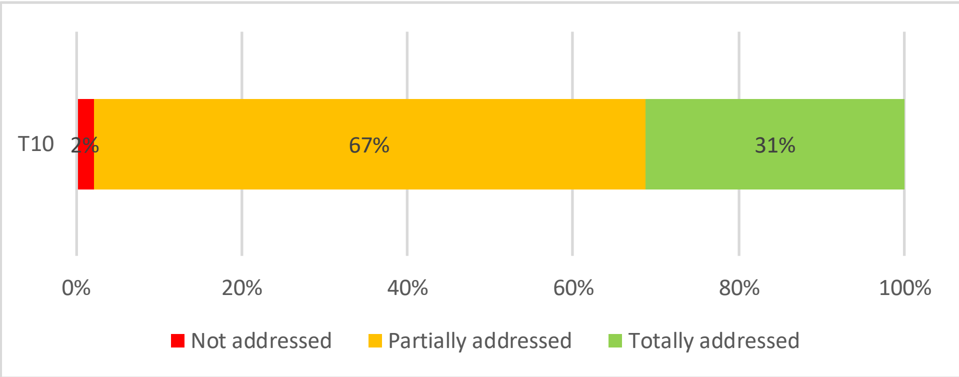
Task 12 could be merged:

- with **task 11** “Asses the value of hybrid technology projects, for example mixing technologies able to perform a high number of cycles with other less CAPEX intensive technologies".
- with **task 7** since services take part of the markets.

General conclusion for the coverage of the functional objective

- Part of the aspects of the tasks have been covered by specific projects.
- The need of broader study, development of general tools and consideration of additional types of storage technologies is highlighted.
- In terms of evolution for the tasks: the tasks shall be reformulated or merged so as to address common topics (benefits, hybrid technologies, etc.)

⇨ **Final coverage of the Functional objective:**



T11 - Demand response, tools for using DSR, load profile, EV impact

List of tasks included in this functional objective

1. Define demand requirements and data required by TSOs for optimal DSR utilization
2. Demonstrate active customer (industry, tertiary sector and end consumers) involvement using “indirect” (provided post-consumption) and “direct” (real-time) feedback, in order to achieve a reduction in peak demand
3. Integrate and demonstrate DSR and storage solutions, including the impact of transport system electrification (e.g., transport EVs, etc.) for off-peak hours, and their use in system balancing
4. Develop simulation tools to include Vehicles to Grid capacity
5. Model customer/load behaviour and segmentation, and quantify the degree of flexibility provided by distribution networks, e.g., through reconfiguration or other methods
6. Test DR models that bring demand response from private customers by, e.g., limiting the rated power during a specific period of time
7. To increase communication campaigns, to develop social impact studies and increase the involvement of local and territorial bodies in the early stage of planning of the infrastructure
8. To assess the value for the system provided by flexible generation

List of projects considered

The following projects (17 projects in total including 12 EC-funded projects) have participated in the survey and claimed to contribute to Functional Objective T11.

FP7/H2020 projects		**Other projects**
ANYPLACE	INTERPLAN	CECOVEL
ARROWHEAD	OSMOSE	CLOUDGRID
eBADGE	PLAN4RES	NEDO
FLEXITRANSTORE	RESERVE	NEXUS
FutureFlow	TILOS	Power Off and Save
GRIDSOL		SIREN

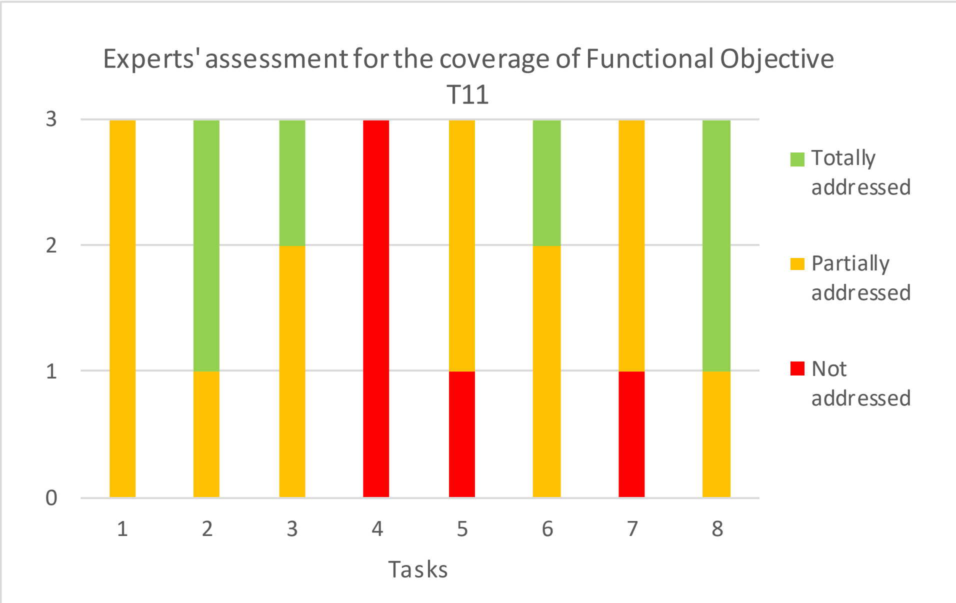
List of experts consulted

The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the topics listed within Functional Objective T11.

Organisation	**Name**
CENER	Gabriel Garcia
REE	Miguel Lorenzo Sotelo
VITO	Grietus Mulder

Overview of the coverage of the Functional Objective according to experts’ views

Two tasks (**tasks 2 and 8**) are considered as totally and partially addressed. For **tasks 3 and 6**, two experts considered it was partially covered whereas one expert considered it was fully covered. **Tasks 1, 5 and 7** were considered as partially covered (with one expert estimating **tasks 5 and 7** as not addressed), whereas **task 4** has been assessed as not addressed at all by the analyzed projects.



Overall achievements reached under this Functional Objective

Task 1 is touched by many projects and in various ways, but not necessarily with a TSO look. Solutions vary from almost physical data communication to a need in change of market conditions.

Several projects covere quite well **task 2** in a complementary way. This topic has already been addressed in specific countries in which TSOs operate large demand response pools daily.

The CEVOVEL project addresses part of **task 3**, i.e. the management of the charging of EVs in low demand hours in order to allow a better use of the available energy while reducing the number of renewable generation disconnections (wind power). By anticipating the behaviour of EV charging and offsetting its high variability, the quality and security of supply can be guaranteed.

Regarding **task 5**, the modelling of customer/load behaviour and segmentation, and the quantification of the degree of flexibility provided by distribution networks has been partially addressed, mostly limited to load behavior (several methods like automatic learning up to central planning).

Several projects covered **task 6** partially up to fully for different end consumers.

As regards **task 8**, the main goals of the investigated projects are to study the impact for the system provided by flexible generation.

Main gaps to cover this functional objective

Regarding **task 1**, data required by TSOs should be preliminary defined to create a mechanism suitable for TSOs.

Even though **task 2** is considered as well covered, it is recommended to further investigate the use of active customer involvement (industry, tertiary sector and end consumers) in order to achieve a reduction in peak demand especially when using “indirect” (provided post-consumption) feedback.

Concerning **task 3**, projects, such as FutureFlow, investigate the role of large power consumers and distributed generation owners to progressively become secondary reserve market providers (as well as redispatching service providers), but it is not clear if they are considering transport (and consequently EVs). Other projects indicate to cover partially this topic, probably since they are not targetting transport systems explicitly except CECOVEL. Experts state that there is lack of physical demonstrators addressing the task.

Customer/load behaviour has been included in projects but segmentation and quantification of the flexibility has not clearly been addressed. As a consequence, **task 5** remains fairly uncovered.

Task 7 has a very little coverage limited coverage considering the importance of this problem: communication campaigns, to develop social impact studies and increase the involvement of local and territorial bodies must be implemented and assessed in the early stage of planning of the infrastructure.

Most projects addressing **task 8** included some way of modelling the performance of Demand Response resources, but few mention the assessment of the value obtained through flexibility measures.

Proposal of evolution for the tasks

Task 1 should be kept and addressed from the TSO point of view.

Task 2 could be merged with **task 7**.

Task 3 could be merged with **tasks 4, 5, 6 and 8**.

Task 4 could be:

- merged with **tasks 3, 5, 6 and 8**;
- reformulated since simulations of V2G capacity can be made from very different perspectives. It is recommended to cover a more specific subject.

Task 5 could be:

- merged with **tasks 3, 4, 6 and 8**;
- reformulated and divide topic into two tasks: behaviour and segmentation could be studied in a qualitative manner, while flexibility can be addressed quantitatively (especially in a distribution network).

Task 6 could be merged with **tasks 3, 4, 5 and 8**.

Task 7 could be:

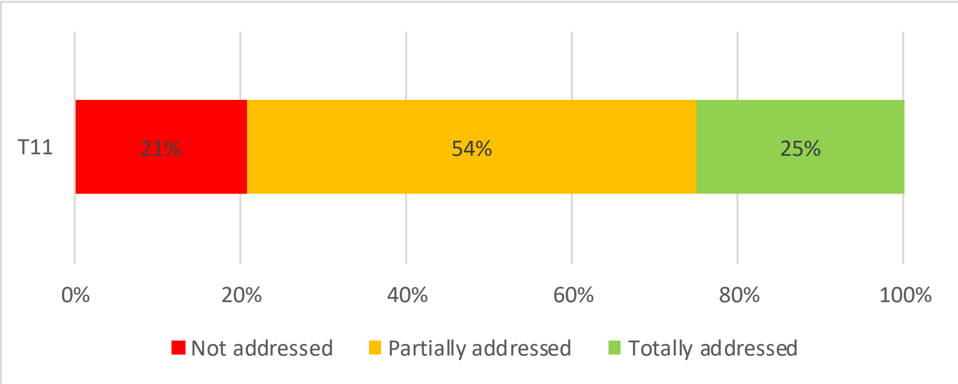
- merged with **task 2**;
- reformulated with a focus on Community driven network upgrade by putting people before technology. Experts recommended limiting the scope to the involvement of local and territorial bodies in the early stage of planning of the infrastructure.

Task 8 could be merged with **tasks 3, 4, 5 and 6**.

General conclusion for the coverage of the functional objective

- While one task has been considered as not addressed at all, experts noted significant gaps in the tasks partially addressed regarding the knowledge of the real value brought by demand response. Most projects did not sufficiently address the topics of the functional objective from the point of view of TSOs.
- In terms of evolution for the tasks: modelling topics should be merged, so seven tasks could form two new tasks. Most topics should be kept and be addressed from the TSO point of view.

⇨ **Final coverage of the Functional objective:**



T12 - Improved RES forecasting and optimal capacity operation

List of tasks included in this functional objective

1. Improve RES forecast accuracy by testing hybrid approaches that combine weather forecasting, local ad-hoc models, historical data, and on-line measurement. Measure improvements in accuracy due to use of high-performance computers. Validate integration scenarios in which the network becomes more user-friendly and can cope with variable generation from RES
2. Develop and demonstrate methods for dynamic capacity management and reserve allocation that support system operations with large amounts of RES integration
3. Estimate secondary/tertiary power reserves against RES forecast accuracy/error
4. Design and demonstrate market tools and investment incentives that support and promote RES generation flexibility, together with conventional sources of energy, for optimal balancing of the power system and ensuring system adequacy and efficiency

List of projects considered

The following projects have participated in the survey and claimed to contribute to Functional Objective T12.

FP7/H2020 projects		**Other projects**
FLEXITRANSTORE FutureFlow GRIDSOL	OSMOSE RESERVE TILOS	CEDREN HydroBalance NEDO NEXUS SINCRO.GRID

List of experts consulted

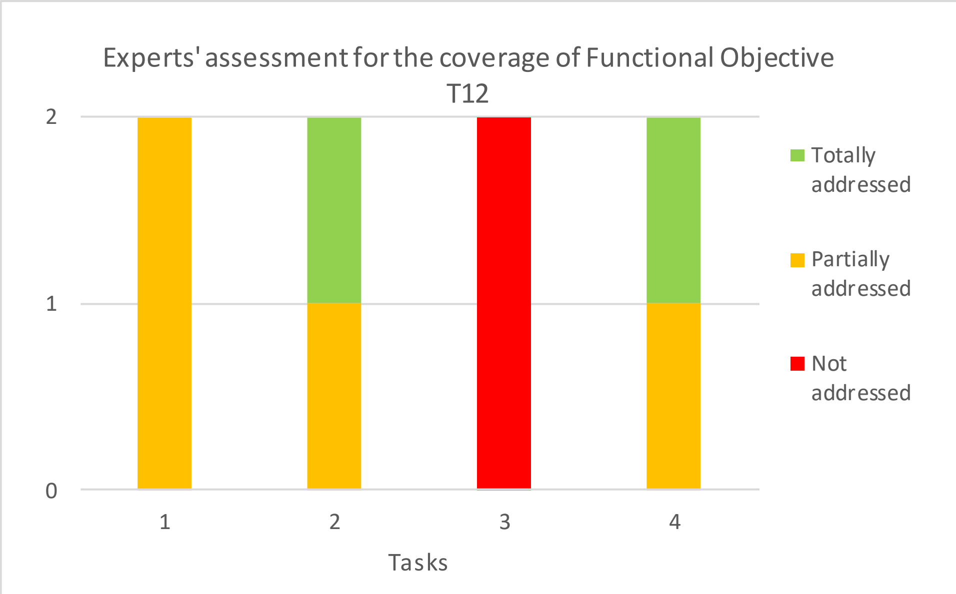
The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective T12.

Organisation	**Name**
REE	Miguel Lorenzo Sotelo
VTT	Seppo Hänninen

Overview of the coverage of the Functional Objective according to experts' views

Task 3 has been considered as not addressed by all the experts. **Task 1** has been unanimously assessed as partially addressed.

Finally, experts are divided on **tasks 2 and 3** as they have been considered as partially or totally addressed.



Overall achievements reached under this Functional Objective

Regarding **task 1**, FutureFlow and OSMOSE reported that they fully developed better RES forecast accuracy, data management and validation of the integrated scenarios.

Considering **task 2**, RESERVE project developed and demonstrated new techniques for frequency and voltage management with up to 100% RES. Also, the Dynamic Output Manager of Energy (DOME) from GRIDSOL facilitated RES integration.

SINCRO.GRID addressed **task 3** regarding the development of voltage control.

Regarding **task 4**, FLEXITRANSTORE developed a market platform that remunerates flexibility services. About optimal balancing ensuring system efficiency, TILOS contributed with forecasting platform including load demand and RES.

Main gaps to cover this functional objective

Projects that contributed to the **task 1** must focus on improving the prediction of renewable generation accuracy rather than considering the integration of renewables. Reported projects need forecasts integrating RES and other resources into network operation.

Solutions linked with **task 2** have only been validated on lab, real experimentations are the next step.

Considering **task 3**, projects must further study voltage control combining secondary/tertiary power reserves and RES forecast generation

Regarding **task 4**, no project reported to design and demonstrate investment incentives.

Proposal of evolution for the tasks

Task 1 could be:

- merged with **task 3**;
- reformulated as "Validate integration scenarios in which the network becomes more user-friendly and can cope with variable generation from RES";
- reformulated as "Improve RES forecast accuracy by testing hybrid approaches that combine weather forecasting, local ad-hoc models, historical data, and on-line

measurement. Validate integration scenarios in which the network becomes more user-friendly and can cope with variable generation from RES".

Task 2 could be reformulated as "Develop methods for dynamic capacity management and reserve allocation that support system operations with large amounts of RES integration".

Task 3 could be:

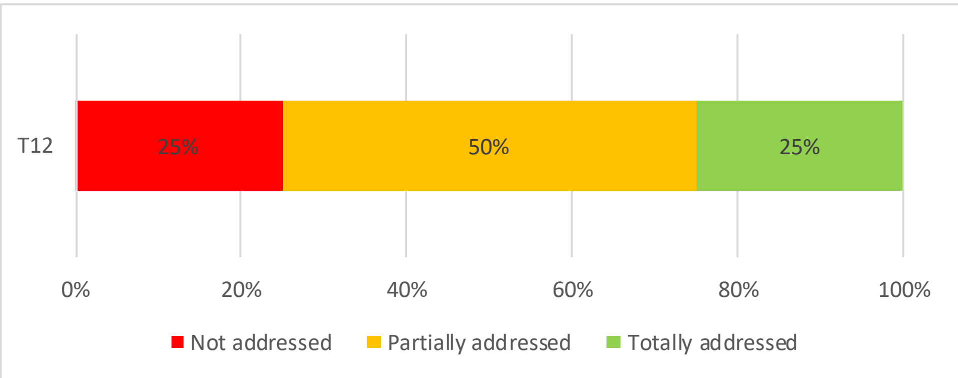
- merged with **task 1**;
- reformulated as "Develop methods for supplying secondary and/or tertiary reserves using environmentally friendly technologies and conventional sources of energy depending on the RES forecast error".

Task 4 could be reformulated to create a new task focusing on regulatory aspects and investment incentives.

General conclusion for the coverage of the functional objective

- Real experimentations, outside the lab, are requested to move forward on most of the tasks.
- In terms of evolution for the tasks: two tasks could be merged; also reformulation are advised and a new task could be created linked to regulatory and investment incentives.

⇨ **Final coverage of the Functional objective:**



T13 - Flexible grid use: dynamic rating equipment, power electronic devices, use of interconnectors

List of tasks included in this functional objective

1. To demonstrate the degree to which transfer capacity can be increased by means of new operating schemes available through the implementation of different approaches and technologies; to investigate all possible technical solutions within the domain of each application; to perform cost-benefit analyses of different case studies
2. To demonstrate power flow control devices that offer increased flexibility with respect to energy flows across multiple transmission zones and borders
3. To demonstrate controllable off- and on-shore solutions for the vendor-independent, HVDC multi-terminal networks used to coordinate power flow, frequency control and coordinate protection and communications requirements
4. Apply more DLR solutions, to become a standard practice for short term congestion and peak transmission line overloads
5. To investigate the 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
6. To investigate HVDC reliability, especially for multiterminal and/or meshed DC grids

List of projects considered

The following projects have participated in the survey and claimed to contribute to Functional Objective T13.

FP7/H2020 projects		Other projects	
ARROWHEAD FLEXITRANSTORE OSMOSE	PLAN4RES	DLR HVDC LINK MMC	Powerline Guardian/ Tower Router SINCRO.GRID SIREN

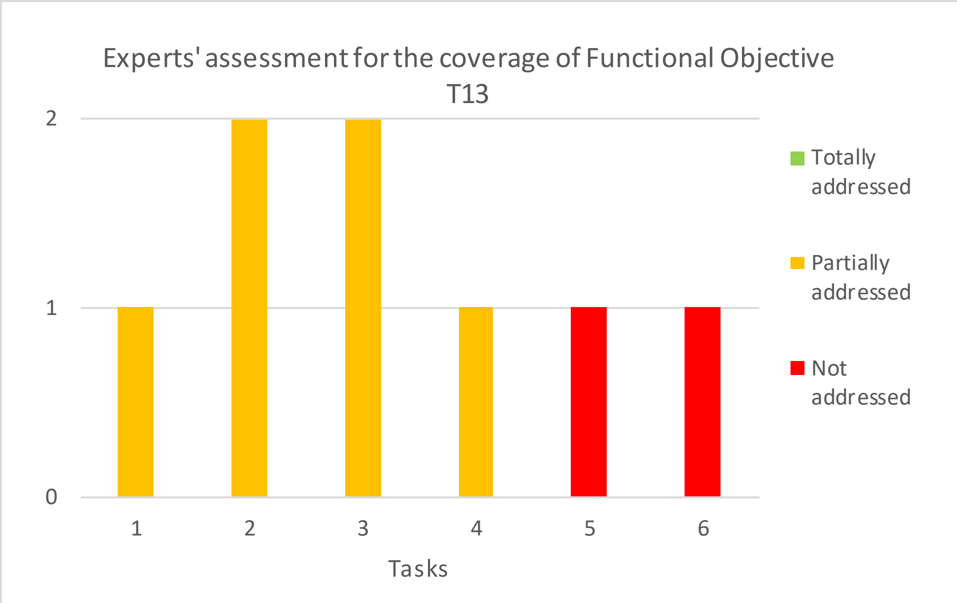
List of experts consulted

The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective T13.

Organisation	Name
REE	Miguel Lorenzo Sotelo
TECNALIA	Eduardo García Quincoces

Overview of the coverage of the Functional Objective according to experts' views

Two tasks have been considered as not addressed by the expert consulted (**tasks 5 and 6**). Other tasks have been judged as partially addressed.



One expert partially answered to the six tasks, as he covered the **tasks 2, 3 and 6** explaining the fact that some tasks have only one expert's assessment.

Overall achievements reached under this Functional Objective

Regarding **task 1**, projects such as OSMOSE introduced coordinated control of a flywheel and a hybrid storage including battery, super-capacitors.

Projects have been able to provide interesting capabilities for **task 2** in terms of power flow control or voltage regulation, while technical capabilities have been generally proven.

Regarding **task 3**, external EU funded projects such as TWENTIES[10], BESTPATHS[11] and PROMOTION[12] controled mutiterminal and meshed HVDC links, detected interoperability issues in multivendor HVDC links, and studied the operation of DC fault detection and clearing algoritmhs.

Considering **task 4**, existing DLR solutions have not yet reached a mature development (in terms of cost for the whole life-cycle and in terms of reliability) to be considered as attractive, considering existing TSO regulatory framework.

Other EU funded projects TWENTIES[4] and PROMOTION[5] addressed some aspects of **task 6.**

Main gaps to cover this functional objective

Considering **task 1**, TSOs are still lacking comprehensive methodologies on "singular" assets (such us DLR, power flow control devices, HVDC interconnectors) to provide a common framework for investment-decision discussion with NRA's.

Future developments on **task 2** must be strongly oriented on increasing the cost-efficiency of this solutions, with detailed research on industrialization and standarization drivers. Also, interesting features could be focused on minimization of the footprint, energy-eficiency, scalability or portability of the solution.

[10] More details on http://www.ewea.org/fileadmin/files/library/publications/reports/Twenties_report_short.pdf

[11] More details on http://www.bestpaths-project.eu/

[12] More details on https://www.promotion-offshore.net/

Regarding **task 4**, in order to increase benefit from DLR sensor, the forecasting models and tools must be a priority. Potential synergies with other topics (RES forecasting) and specially with the rise of (deep) machine-learning techniques should be the path of the future.

Task 6 could be clarified as experts were not sure if the topic consisted to study HVDC reliability from the technology point of view or in relation with.

Proposal of evolution for the tasks

Task 1 could be reformulated to create a new task "Development of methodologies in order to provide assistance for optimal technology selection incorporating efficiency of the investment and system security criteria".

Task 2 could be either**:**

- change in a new task "Development of methods and tools to analyse and monitorize in real time the stability of power systems highly engaged by power electronics devices providing ancillary services";
- reformulated to focus on the research on the drivers for cost-efficiency.

Task 3 could be:

- merged with **task 6**
- divided to create several tasks:
    - "New power electronics solutions for HVDC links to reduce costs and to enhance flexibility and power management (such as DRU, development of DC/DC converters, alternative topologies to the extended MMC, etc.) ";
    - "DC protection relays and DC breakers";
    - "Development of tools and methods to analyse the stability of HVDC links and the interations between HVDC converters, wind farms converters, synchronous generators and power system impedances";
    - "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.)";
    - "Medium voltage DC distribution systems".

Task 4 could be modified to create new tasks related to these two topics:

- "Technical standarization bodies: agree on new methodologies for transmission capacity calculations considering new experience and the availability of additional data coming from DLR solutions";
- "Regulatory bodies: regulatory framework to promote the use of DLR based on the cost-benefit analysis".

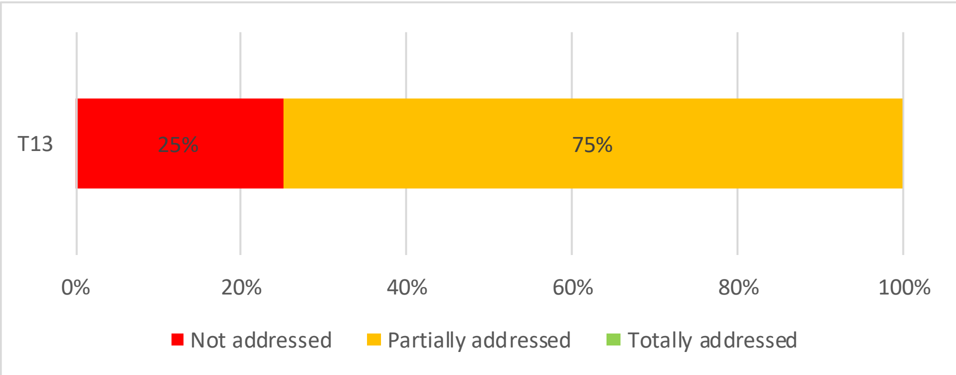
Task 5 did not request specific evolution.

Task 6 could be merged with **task 3**.

General conclusion for the coverage of the functional objective

- The functional objective has not been covered yet as no expert considered any task as fully addressed.
- Tasks need to be clarified or increase the maturity of their technologies.
- In terms of evolution for the tasks: two tasks could be merged; three tasks could inspire the creation of several tasks.

⇨ **Final coverage of the Functional objective:**



T14 - Interaction with non-electrical energy networks

List of tasks included in this functional objective

1. Develop methodologies and tools to assess the impact of the transition towards a new model for a European energy system (heat, transport, gas, electricity)
2. Joint planning
3. Study complex dynamics of the coupled systems when producing large quantities of methane (power-to-gas) to be injected into the gas grid and later used for the production of electricity

List of projects considered

The following projects have participated in the survey and claimed to contribute to Functional Objective T14.

FP7/H2020 projects		**Other projects**
ARROWHEAD H2FUTURE	PLAN4RES RealValue	UNDERGROUND SUN STORAGE

List of experts consulted

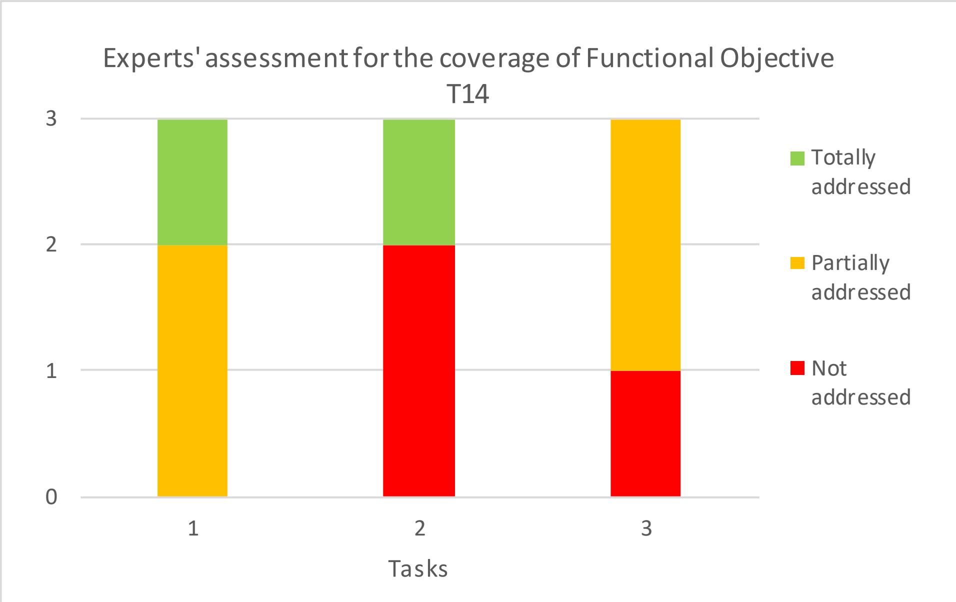
The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective T14.

Organisation	**Name**
DLR	Hans-Christian Gils
REE	Miguel Lorenzo Sotelo
TRACTEBEL	Niels Leemput

Overview of the coverage of the Functional Objective according to experts' views

One task (**task 3**) has been considered as few covered by the expert as it received partially or not addressed assessments.

Task 1 has been assessed as partially or fully covered, while **task 2** received different assessments with one expert that considered the task as totally addressed and two others that assessed it as not addressed.



Overall achievements reached under this Functional Objective

Regarding **task 1**, project PLAN4RES developed a model infrastructure dedicated to the expansion planning and detailed operation modelling of an integrated European energy system.

ARROWHEAD worked on tools for **task 2** that eased joint planning, as PLAN4RES that developed an end-to-end planning and operation tool, able to tackle large shares of renewable.

Considering **task 3**, PLAN4RES and UNDERGROUND SUN STORAGE investigated the coupling of electricity and gas through power to gas applications.

Main gaps to cover this functional objective

Very few projects managed with cross-sectorial analysis studied in **task 1**. Further researches are requested on this topic, involving key players from the different sectors and experts on the different energy vectors.

Regarding **task 3**, gas network model in PLAN4RES and USS did not fully consider all technical challenges related to the injection of synthetic methane into the existing infrastructure, as the gas distribution. Gas network need to be considered in detail in the capacity expansion modelling.

Proposal of evolution for the tasks

Task 1 could be:

- merged with **task 1**;
- reformulated to specify that the impact assessment must be considered on technical and economic aspects, and also sustainability aspect.

Task 2 could be merged with **task 1**.

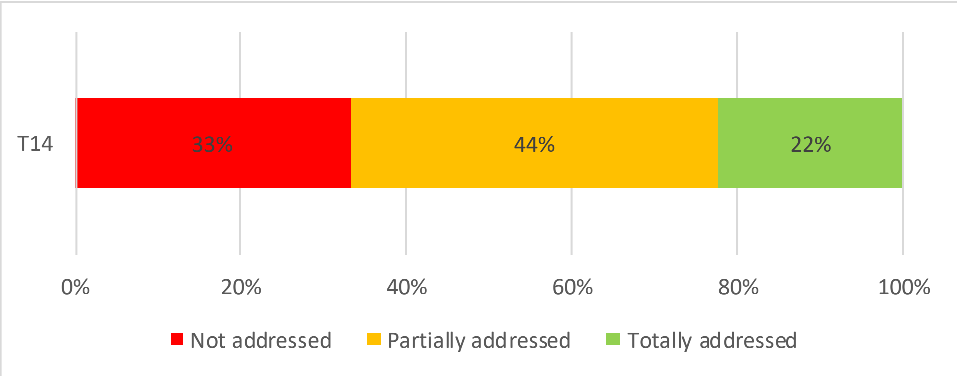
Task 3 could be:

- reformulated as "Study complex 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)";
- modified to create a new task focused on the technological challenges for the gas networks related to the large-scale application of power-to-gas.

General conclusion for the coverage of the functional objective

- Overall, few projects covered the three tasks or even no one. New developments are needed to go further on the issues.
- In terms of evolution for the tasks: two tasks could be merged; other one could be rephrased and inspire a new task.

⇨ **Final coverage of the Functional objective:**



T22 - Flexible thermal power generation

List of tasks included in this functional objective

1. To improve ramping (up and down), i.e. to move within a specified time from a defined idle state to synchronous operation with a defined power output (start-up/shut-down)
2. To further increase the rate at which a thermal generation unit can increase or decrease its output (load following capability)
3. To further reduce the minimum load at which a thermal generation unit can reliably operate
4. To improve performances (efficiency and emissions) at partial loads
5. To increase the fuel flexibility of thermal power plants, to be able to use different sources fuels (mixing and switching)
6. To better control the lifespan (improve robustness and operability) of thermal power plants and decrease the outages due to fast cycling
7. [Cogeneration] To decouple the use of heat & power (e.g. storage, power-to-heat, power-to-gas) so as to better integrate existing and future units in the grid/energy system
8. [Cogeneration] To develop technologies with high electrical efficiency that can use hydrogen, biomass and biofuels

List of projects considered

The following projects have participated in the survey and claimed to contribute to Functional Objective T22.

FP7/H2020 projects		Other projects
ARROWHEAD FLEXITRANSTORE Flexturbine	GRIDSOL PLAN4RES TURBO-REFLEX	FLEXITES KRYOLENS

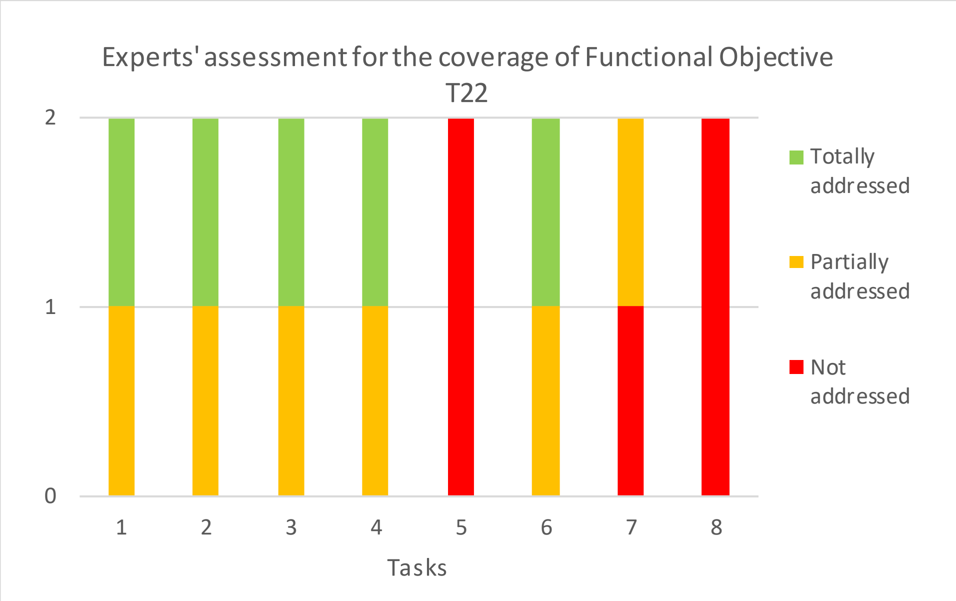
List of experts consulted

The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective T22.

Organisation	Name
CIRCE	Carlos Arsuaga
ENTSO-E	Ioannis Theologitis

Overview of the coverage of the Functional Objective according to experts' views

Among the eight tasks, two tasks have been unanimously considered as not addressed by the experts (**tasks 5 and 8**), and another one has been assessed as partially or not covered (**task 7**). Three-quarter of the tasks have been judged as partially or fully addressed (**tasks 1, 2, 3, 4 and 6**).



Overall achievements reached under this Functional Objective

Considering **task 1**, TURBO-REFLEX and Flexturbine are fully focused on developing high TRL solutions to improve the flexibility (including ramp rate) of power plants. Other projects like GRIDSOL, FLEXITES and FLEXITRANSTORE also contributed to this aim, mainly through energy storage solutions, at different TRL levels.

For **task 2**, coverage is low regarding the capabilities of the thermal plant. Some solutions worked on storage technologies to support flexibility like in KRYOLENS project, but only from the storage view.

TURBO-REFLEX and Flexturbine are the only projects addressing the **task 3** to the core. FLEXITES, GRIDSOL and KRYOLENS proposed different storage technologies (electrochemical, thermal, mechanical) that could fulflill this objective.

Regarding **task 4**, TURBO-REFLEX and Flexturbine pay a particular attention to this topic, developing and testing not only new components and equipment but software tools to achieve a more efficient operation of the plants.

Considering **task 6**, FLEXITES increased the flexibility and operability of the existing plants. Also TURBO-REFLEX and Flexturbine have worked to improve the life cycle of the existing plants, and identify shortcomings and technology updates necessary for the proper operation of those plants in the "new" energy setting.

Only PLAN4RES has worked in crossing the different energy vectors (heating/cooling – transport - electricity coupling) linked to **task 7**.

Task 8 has been addressed by the project GRIDSOL that provided study on bioenergy.

Main gaps to cover this functional objective

Some solutions for doubling the ramp rate of thermal plants have been made in TURBO-REFLEX for instance, but additional testing is needed to complete **task 1**.

Regarding **task 2**, storage integrated in existing plants could be great experimentations to play more with the output of the plant and to optimize costs.

Considering **task 3**, the rest of the projects seem to provide only flexibility options but not reducing the minimum load ensuring reliable (technically) operation.

The listed projects are addressing the **task 4** but upscaling and more testing is needed. Most of the solutions are inferior to TRL6-7 and not ready certified.

Regarding **task 6**, project TRLs level could still be considered as quite low and would need further developments.

Considring **task 7**, the result from PLAN4RES has been a software/operational tool, which still needs further work and testing/validation.

Proposal of evolution for the tasks

Tasks 1 and 2 could be:

- merged between them to improve the ramping of synchronous generation, refering to existing conventional generation;
- merged with **tasks 3, 4 and 6**.

Tasks 3 and 4 could be:

- merged between them;
- merged with **tasks 1, 2 and 6**.

Task 5 could be modified to create a new task aiming at the refurbishment of existing conventional power plants to improve their fuel flexibility (biomass particularly).

Task 6 could be merged with **tasks 1, 2, 3 and 4**.

Task 7 could be merged with **task 8**, to create a new generation of renewable and flexible CHP plants of different size (see also synergies with D14 task).

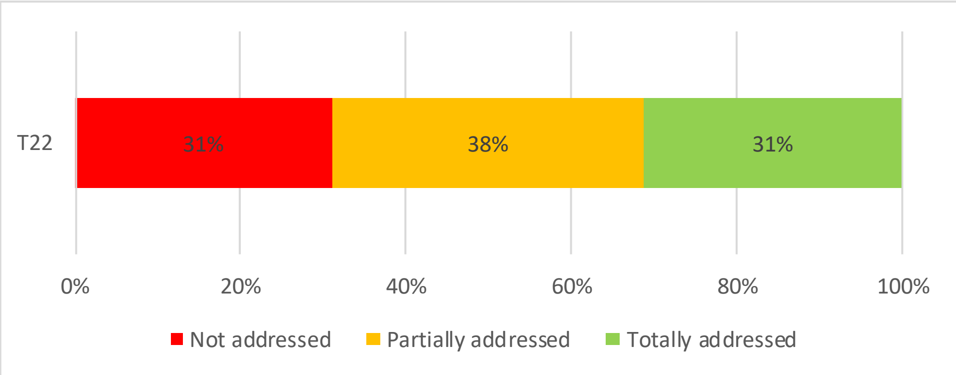
Task 8 could be:

- merged with **task 7**, to create a new generation of renewable and flexible CHP plants of different size (see also synergies with D14 task);
- modified to create a new task related to developing dispatachable renewable plants combining variable reneables with different storage technologies (in the line with GRIDSOL).

General conclusion for the coverage of the functional objective

- A quarter of the tasks has not been addressed by listed projects and another one is divided between not or partially addressed, mainly due to a lack of experimentations.
- Other tasks have been quite addressed thanks to relevant projects, but additional tests have been requested by the experts.
- In terms of evolution for the tasks: seven tasks could be merged and led to the creation of two or three tasks; also two new tasks could be created.

⇨ **Final coverage of the Functional objective:**



CLUSTER C4 – ECONOMIC

T15 - Market/grid operation integration

List of tasks included in this functional objective

1. Validate a flow-based market coupling approach that can be extended geographically and temporally (intraday horizons)
2. Define and validate a stochastic flow-based approach that enables better coordination between the market and the real network capacities
3. Introduce simulation options that account for interactions between the various regulatory frameworks
4. Define the modelling approaches and the associated data on transmission and generation that are vital to delivering meaningful results

List of projects considered

The following projects have participated in the survey and claimed to contribute to Functional Objective T15.

FP7/H2020 projects	Other projects
ARROWHEAD eBADGE EU-SysFlex FLEXITRANSTORE GRIDSOL OSMOSE	ALEGRO CEDREN HydroBalance KRYOLENS NEXUS SMART GRID BATTERY STORAGE PROJECT PROTTES

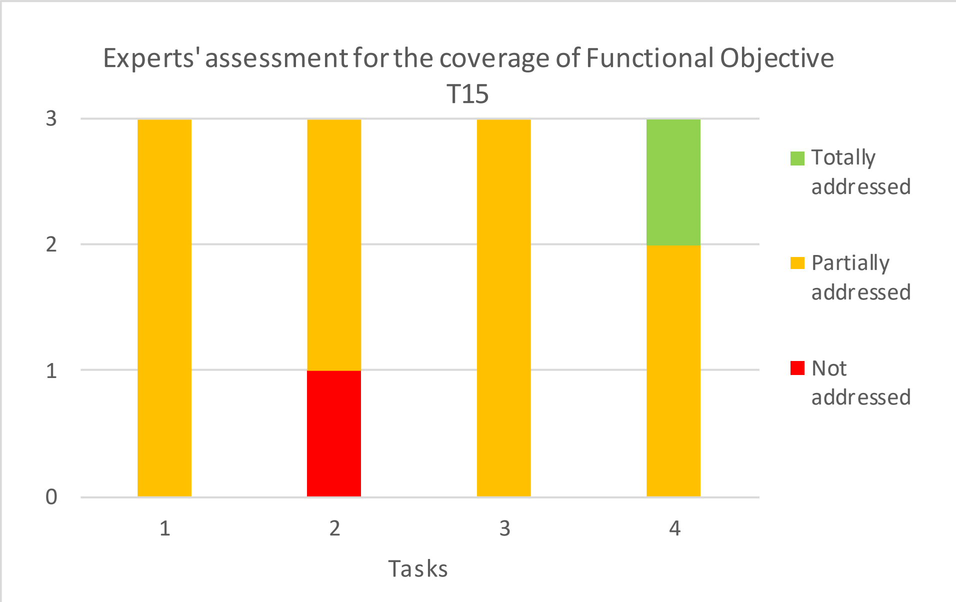
List of experts consulted

The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective T15.

Organisation	Name
ENEA	Viviane Cigoletti
CENER	Raquel Garde
ENTSO-E	Ioannis Theologitis

Overview of the coverage of the Functional Objective according to experts' views

Task 2 has been assessed as partially or not addressed. Experts all agree that **tasks 1 and 3** have been partially addressed by listed projects. Finally, **task 4** has been considered as totally or partially addressed.



Overall achievements reached under this Functional Objective

Considering **task 3**, regulatory assessment was done, as in eBADGE project, which highlighted current frameworks and suggestions for improvements (regulatory and market design).

Main gaps to cover this functional objective

Tasks 1 and 2 still needs to be under investigation, more research work is needed from the project representatives/coordinators. For instance, ALEGRO still need to be implemented and to provide information about validation and extrapolation.

In theory, **task 4** is not much than a RD&I topic, it should be a cross cutting action/objective for any relevant project as this is a matter of transparency. The subject has not been addressed explicitly and information data for national projects has been even more difficult to find.

Proposal of evolution for the tasks

Tasks 1 and 2 could be:

- merged to include geographical and temporal extensions, without specifying the approach (remove stochastic) to open to new options and reinforcing the coordination of market and network operation;
- merged and renamed as “Develop and Validate a new pan-European market design to foster the integration of the emerging technologies (RES, storage, DR, EVs)“.

Task 3 could be:

- reformulated as "Development of future scenarios for the pan-European electricity market through amendments to the current regulatory framework”;
- reformulated to focus on the definition of common rules (common regulation) to push the Internal EU Market, validated by simulations;
- deleted, if in all tools/output proposed in the market design cluster, it runs partial sensitivity analysis for implementation/exploitation reasons.

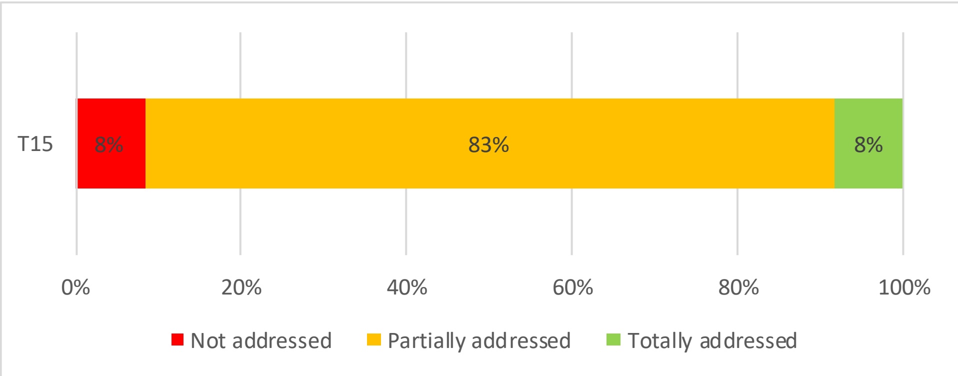
Task 4 could follow two paths:

- focus on proper visibility on data and methodologies/approaches;
- reformulate as "Define the modelling approaches and the associated data on generation that are vital to deliver meaningful result".

General conclusion for the coverage of the functional objective

- Tasks covered still need projects to be implemented, as all the aspects have not been treated.
- In terms of evolution for the tasks: two tasks could be merged, others could be deleted or reformulated.

⇨ **Final coverage of the Functional objective:**



T16 - Business models

List of tasks included in this functional objective

1. Various tools will be developed to model globally the energy sector, taking into account the different roles and actors (carrying these roles) with their own interests, various regulatory frameworks and market designs. The interactions between the roles/actors should be modelled as well. Several tools need to be designed and developed: they involve a global modelling of the major energy carriers, able to account for the different roles and players involved, with their own interests and within different regulatory frameworks and market designs that shape their interactions. All capacity means ought to be considered (demand response, energy storage, generation), regarding their contribution to security of supply

List of projects considered

The following projects have participated in the survey and claimed to contribute to Functional Objective T16.

FP7/H2020 projects		Other projects
ARROWHEAD eBADGE FLEXITRANSTORE GRIDSOL	OSMOSE RESERVE SUNSEED TILOS	CLOUDGRID KRYOLENS

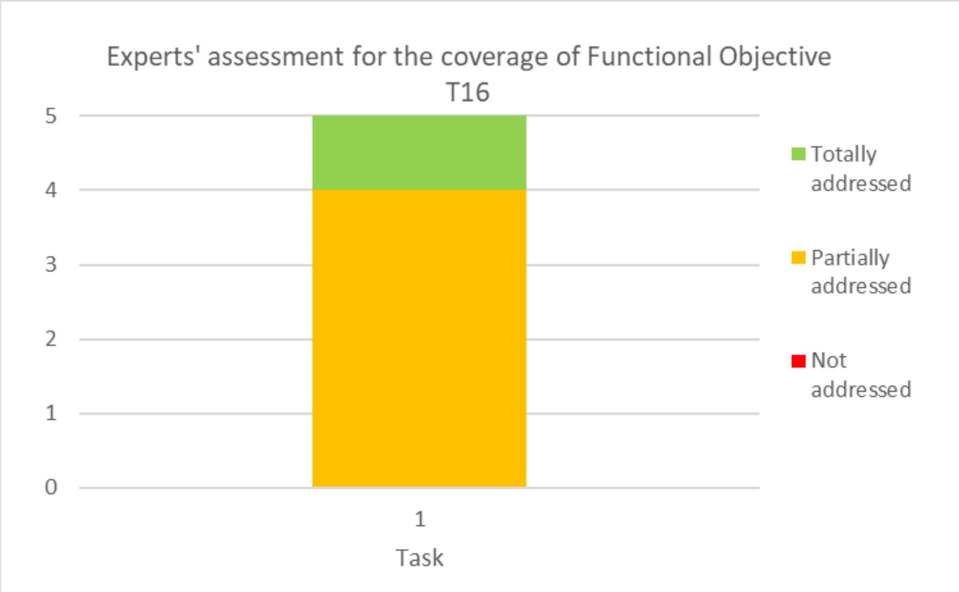
List of experts consulted

The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective T16.

Organisation	Name
CENER	Raquel Garde
MHPS	Torsten Buddenberg Michalis Agraniotis Christian Bergins
RTE	Sabera Mamodaly
TECNALIA	Eduardo García Quincoces
VITO	Kris Kessels

Overview of the coverage of the Functional Objective according to experts' views

The Functional objective is considered, for four experts out of five as Partially addressed.



Overall achievements reached under this Functional Objective

OSMOSE, CLOUDGRID and FLEXITRANSTORE consider a holistic modelling approach to assess the economic value of new flexibility and interaction with other actors and market. KRYOLENS and GRIDSOL focus on modelling specific flexibility such as hybrid RES dispatchable plants and Liquid Air Energy Storage.

Some projects addressed very specific applications [IoT automation (ARROWHEAD), frequency management and voltage control (RESERVE), monitoring of electricity distribution grids (SUNSEED)] and/or technologies [Hybrid RES Dispatchable plants (GRIDSOL), Liquid Air Energy Storage (KRYOLENS)]. Other projects develop tools which can be used to carry out a more global analysis such as the methodology developed within CLOUDGRID to evaluate the benefits and risk associated when providing ancillary services, the transnational balancing market simulator developed within eBADGE and the wholesale market simulator for flexibility services developed within FLEXITRANSTORE. Overall the OSMOSE tools methodology allows to forecast the optimal mix of flexibility solutions at pan-European level.

Moreover, some projects perform assessments of the economic impacts of the solutions proposed at the level of the power system (e.g. BADGE and GRIDSOL). Some others perform business model analysis for the investors involved (e.g. FLEXITRANSTORE, KRYOLENS and GRIDSOL).

Main gaps to cover this functional objective

None of the tools/methodologies developed within the considered projects seems to cover the different aspects of the task (global modelling, different energy carriers, different roles and players, different regulatory frameworks and market designs, different technologies i.e demand response, energy storage, generation). More precisely, focus on the economic impacts for each of the actors involved shall be further developed such as business model analysis for the entire value chain (and not only for the investors involved). Models are local or too simple or do not take into account diverse regulatory frameworks, etc. and results are not enough representative or easily transferred to a real regulatory framework and market. The global perspective of the aspects of the task shall be addressed.

Proposal of evolution for the tasks

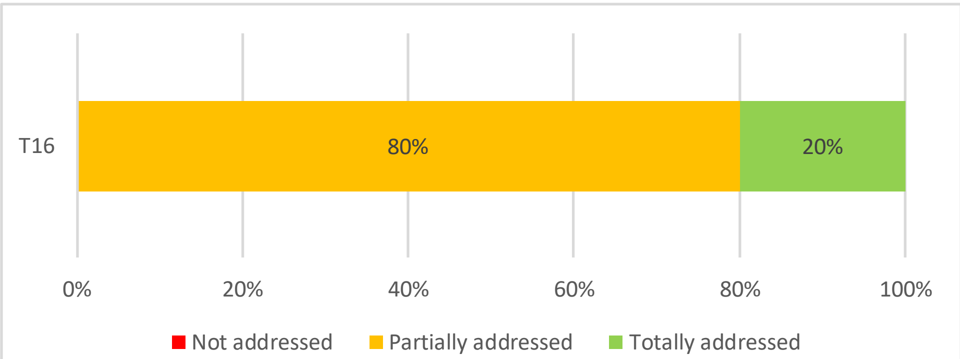
The task could be:

- reformulated based on several options:
    - "Various tools need to be designed and developed that can drive optimal investments needed to enable/speed up the energy transition and achieve decarbonization goals. They should involve a global modelling at EU level of the major energy carriers (gas, electricity, heat, etc.). All flexibility means ought to be considered (demand response, energy storage, generation, transmission) for the different energy carriers, regarding their contribution to security of supply and the decarbonization/CO2 emission reduction goals. The tools should allow to determine the impact of implementing different market designs options and accompanying regulatory frameworks and should be able to account for the behavior of the different actors involved with each their own interest.";
    - "Integration of the assessment of the impact of the solutions proposed at power system level, with a more detailed business model analysis, which identifies the required business model for the investor, but also its impact on the rest of the value chain, to better estimate the feasibility of the proposed solution. Moreover, the task should be extended to also cover distribution systems, as the challenges related to investments will also affect this part of the power system.";
    - "Highlight the necessity of modelling not the current systems but future scenarios with new common rules for all Europe. It is important to identify the influence of modifying one parameter in other terms of market design and remuneration schemes, e.g. how deployment of new technologies such as storage, EV, P2X, etc. impacts in developed technologies businesses.";
- focused on EU scale after taking into account interconnections of Europe with other continents (e.g. Asia, Africa) and with the worldwide energy carrier markets (import oil, coal/biomass, natural gas etc.).

General conclusion for the coverage of the functional objective

- Several tools developed within the projects considered covering some aspects of the task;
- Specific aspects of the task to be considered to fully cover the functional objective (development of tools/methodologies, etc.);
- In terms of evolution for the tasks: the task shall be reformulated (several options possible).

⇨ **Final coverage of the Functional objective:**



T17 - Flexible market design

List of tasks included in this functional objective

1. Short term: Develop models and simulation tools to demonstrate the results of enforcing specific market designs for integrating renewables into power balancing and system services, while accounting for infrastructure development. In this way, RES can be freely integrated into the electricity market and the generation shift and power balance can be improved without interrupting the quality and reliability of service
2. Longer term: Develop market models to drive more cost-effective investments in a coordinated approach. Design mechanisms that assure both system adequacy and system security. Define demand requirements and data required by TSOs for optimal DSR utilization; Demonstrate active customer (industry, tertiary sector and end consumers) involvement using "indirect" (provided post-consumption) and "direct" (real-time) feedback, in order to achieve a reduction in peak demand

List of projects considered

The following projects have participated in the survey and claimed to contribute to Functional Objective T17.

FP7/H2020 projects		**Other projects**
ARROWHEAD EU-SysFlex FLEXITRANSTORE	GRIDSOL OSMOSE RESERVE	NEDO NEXUS STORAGE LAB

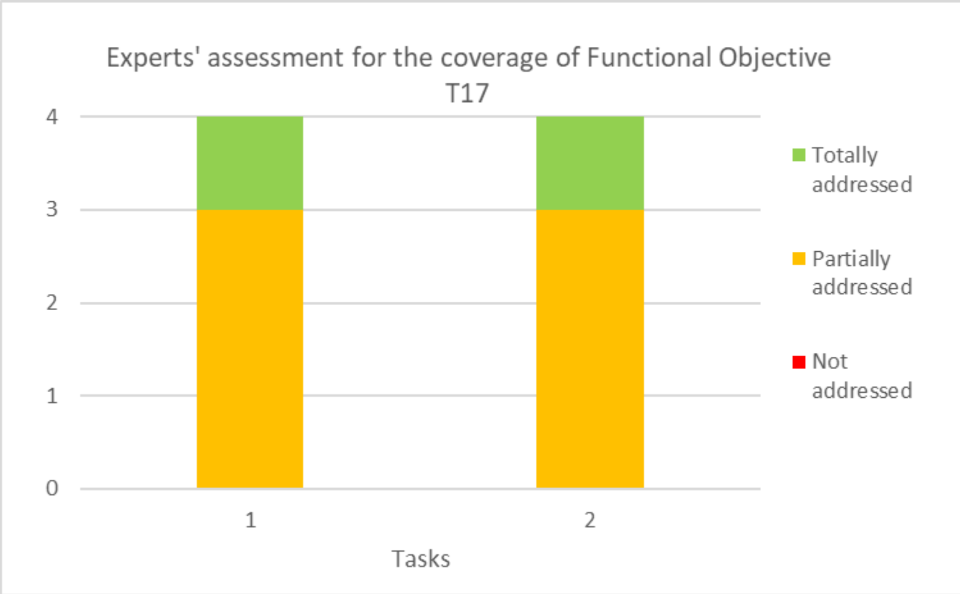
List of experts consulted

The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the topics listed within Functional Objective T17.

Organisation	**Name**
MHPS	Michalis Agraniotis
RTE	Sabera Mamodaly
TRACTEBEL	Frederic Tounquet
VITO	Kris Kessels

Overview of the coverage of the Functional Objective according to experts' views

The two tasks (**tasks 1 and 2**) are considered both partially and totally covered (three of the four experts assessed the tasks as partially covered).



Overall achievements reached under this Functional Objective

FLEXITRANSTORE and OSMOSE projects are addressing some aspects of **task 1.** FLEXITRANSTORE is focusing on how to integrate flexibility services remuneration in the existing EU wholesale market design and OSMOSE forecast the optimal mix of flexibility solutions at pan-European system level, maximising social welfare, with a holistic approach of the power system, with a focus on synergies across flexibility sources and applications. The tool proposes improvements of the existing market mechanisms and regulatory frameworks, to trigger the deployment of the optimal mix of flexibilities, and especially to capture the synergy values. One result of the GRIDSOL project is The Dynamic Output Manager of Energy (DOME) which is a power plant controller of a Smart Renewable Hub (SRH). It deals with the question of: how optimize the use of different local flexibilites (RES Hub with solar panels, thermal storage, etc. depending (among other things) on state of market.

Several projects addressed aspects of **task 2**. First, the EU SysFlex project will provide recommendations on market models that can enable increased flexibility without reducing system adequacy and security. The project will use different market modelling approaches to provide recommendations. Moreover, the project will develop a flexibility roadmap focusing on the actions to be taken to maximise the levels of scalability and replicability (SR) of the flexibility solutions developed and demonstrated. It will help assuring the widespread deployment of solutions that have proven their ability to address the technical shortfalls, thus presenting a potential for tangible benefits to the pan-European cost-effective system by reducing system costs and CO2 emissions reduction. Then, in the Nexus project an integrated modelling platform is proposed covering decentralized generation, electricity networks, generation dispatch, system security analysis, and considering the impacts of alternative market designs for electricity. Finally, the OSMOSE project provides recommendations for improved market design.

Main gaps to cover this functional objective

Regarding **task 1**, no comprehensive model or tool has been developed that integrate flexibility in balancing and system services while accounting for the infrastructure development. Feedback from the market perspective seems to be missing as well as accurate simulations representing upcoming market conditions.

Regarding **task 2**, the EU-SysFlex project only cover system services, and all time frames shall be covered. Simulation tools to steer investments in RES in a more general way shall be considered.

Proposal of evolution for the tasks

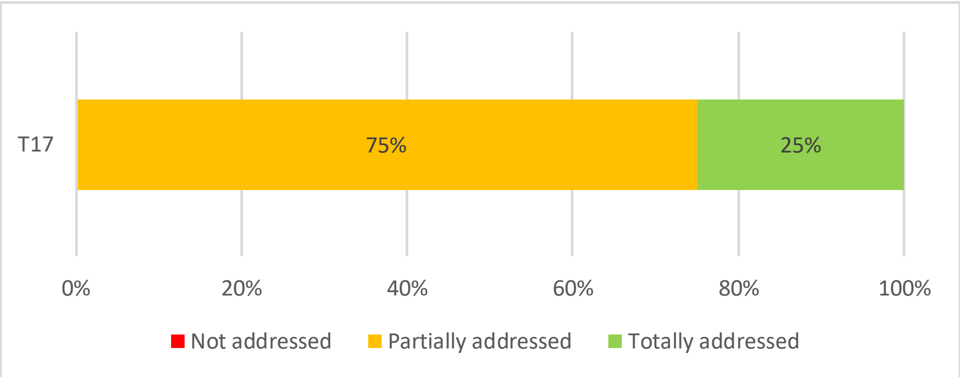
Regarding **task 1** and **task 2**, several options shall be considered:

- create a new task: Develop models and simulation tools to demonstrate the results of enforcing specific market designs for integrating renewables into adequacy services, achieving a greater balance between Affordability, Security of supply and Use of existing infrastructure;
- merge the task with **task 2** the following way: "Develop a simulation toolbox to drive more cost-effective investments in RES in a coordinated approach, assuring both system adequacy and system security, at EU level. The toolbox should be able to cover all time horizons and markets (from investment planning until real-time) and should take into account the effects of alternative market designs and the potential for infrastructure development. All flexibility means ought to be considered (demand response, energy storage, generation, transmission), including cross-carrier flexibility";
- merge the task with the **Functional Objective T16** addressing Business Models aspects.

General conclusion for the coverage of the functional objective

- Some aspects of the tasks are covered by several projects but further development shall be considered to totally address them;
- In terms of evolution for the tasks, the tasks could be, among others, merged with T16 "Business Models".

⇨ **Final coverage of the Functional objective:**



CLUSTER C5 – DIGITALIZATION OF POWER SYSTEM

T18 - Big Data Management

List of tasks included in this functional objective

1. Develop a strategy for beneficial and relevant Big Data management initiatives within ENTSO-E through the use of relevant case studies. Develop, together with DSOs, ICT providers' protocols for data transfer, utility business models and decision-making support. Develop interfaces between Big Data management and the existing planning and operational tools
2. Develop infrastructures or tools able to manage bigdata from different sources: planning tools, management tools, Smart-meters, social medias, etc.
3. Supporting advanced market platforms

List of projects considered

The following projects have participated in the survey and claimed to contribute to Functional Objective T18.

FP7/H2020 projects	Other projects
GRIDSOL	Energy Data Service Integrated IT-Systems

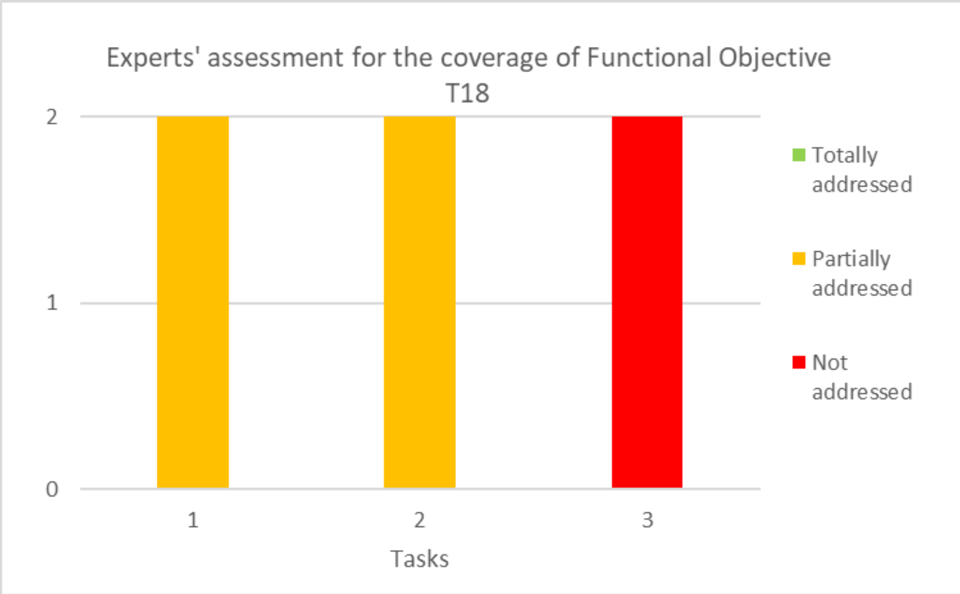
List of experts consulted

The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective T18.

Organisation	Name
MHPS	Michalis Agraniotis
RTE	Sabera Mamodaly

Overview of the coverage of the Functional Objective according to experts' views

The tasks are unanimously assessed: partially addressed (**task 1** and **task 2**) and not addressed (**task 3**).



Overall achievements reached under this Functional Objective

Regarding **task 1**, the GRIDSOL project develops a power plant controller of a Smart Renewable Hub managing plenty of data from controllers and sensors ensuring the optimal techno-economic dispatch of electricity among generators and storage systems.

The Integrated IT System project aims at facilitating the integration of different tools and data from different sources in Amprion IT-internal landscape in line with **task 2**.

Main gaps to cover this functional objective

Strategy on big data management or relevant communication protocols shall be further developed to fully cover **task 1**.

Task 3 is not addressed at all.

Proposal of evolution for the tasks

Task 1 could be:

- kept as it is;
- merged with **task 2**

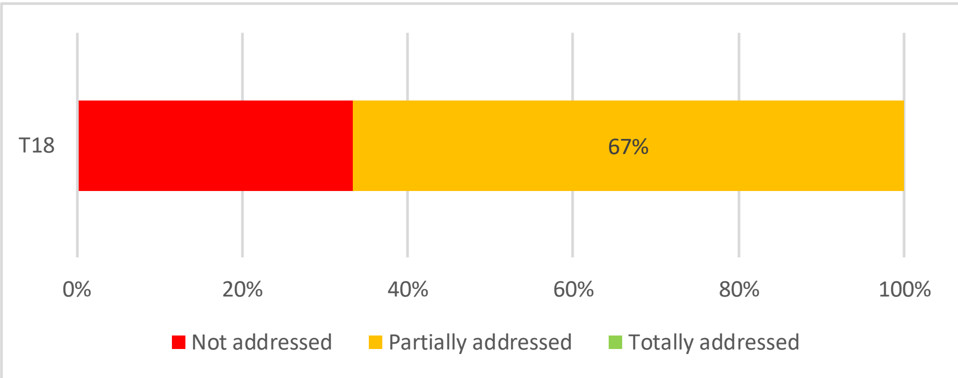
Task 3 could be:

- kept as it is;
- clarified to m ake it les generic;
- merged with **task 1** and **2**.

General conclusion for the coverage of the functional objective

- Two tasks partially addressed and one task not addressed;
- In terms of evolution for the tasks, the tasks shall be merged or clarified (**task 3** too general).

⇨ **Final coverage of the Functional objective:**



T19 - Standardisation, protocols for communication, and data exchange

List of tasks included in this functional objective

1. 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
2. Application guidelines and recommended practices for implementation
3. Identify needs for maintaining existing standards
4. Develop standards for new needs in protocols services or extensions to existing standards
5. Promote standardized information exchange solutions based on standardized protocols
6. Promote use of open source initiatives
7. To specify and define the specific interchange Data model between TSO-DSO, TSO-other agents (such as demand aggregators, EV charging managers…) in order to ensure the flexible operation of the network

List of projects considered

The following projects have participated in the survey and claimed to contribute to Functional Objective T19.

FP7/H2020 projects		**Other projects**	
ARROWHEAD eBADGE FutureFlow	MIGRATE OSMOSE RESERVE	CECOVEL DIGITALIZATION OF THE VIDIŠKIAI TRANSFORMER SUBSTATION	Energy Data Service HEILA Integrated IT-Systems NEDO

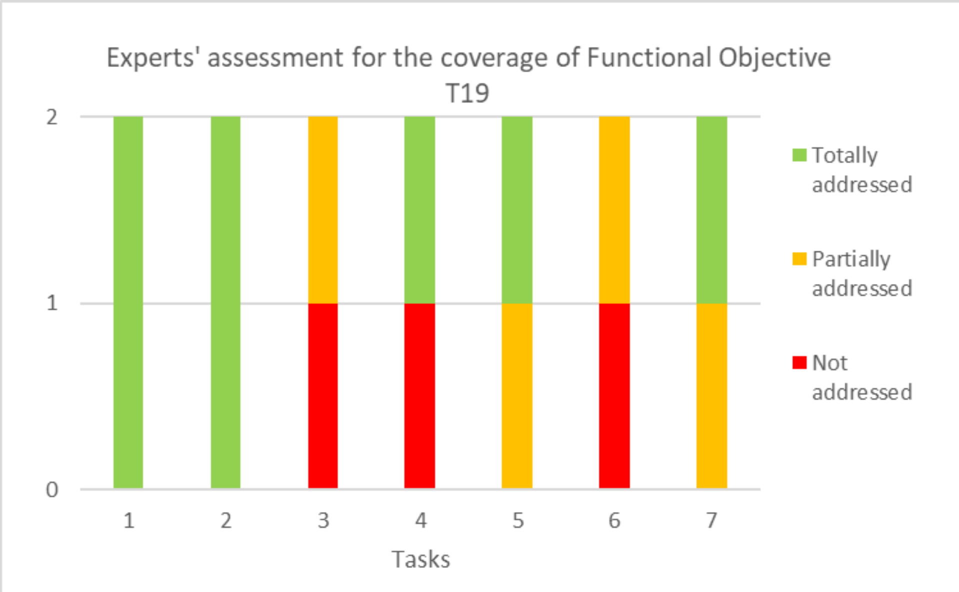
List of experts consulted

The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective T19.

Organisation	**Name**
MHPS	Michalis Agraniotis
RTE	Sabera Mamodaly

Overview of the coverage of the Functional Objective according to experts' views

Two tasks are unanimously addressed (**tasks 1** and **2**), two tasks are assessed both partially and not addressed (**tasks 3 and 6**), two tasks are assessed both totally and partially addressed (**tasks 5 and 7**) and one tasks has a divergent assessment as totally and not addressed (**task 4**).



Overall achievements reached under this Functional Objective

Regarding **tasks 1** and **5**, several projects addressed aspects of the tasks: the digital substation of Vidiskiai project explicitely mentions recommendations on protocol CEI 61850; the integrated IT Systems of Amprion develops an internally data model for grid data exchanges related to CIM model; the RESERVE project develops 5G network communication and CIM grid model for pan european simulation to test voltage and frequency control concept; the OSMOSE project may use communication protocols for grid forming demonstrator and coordinated control of different storage and FACTS devices (protocols not explicitely mentionned); the other projects covering this task deal with balancing market (e-badge, Future Flow, NEDO) and may use CIM standard (but not explicitely mentionned).

Regarding **task 2**, in addition of the previous list of projects, HEILA and MIGRATE projects specifically point this task out (and not the previous one) because of their implemented platform.

Regarding **task 3,** some projects are mentioning "new" standards to develop and implement.

Regarding **task 4**, some projects address new needs: RESERVE addressed CIM model and 5G used for pan-european simulation (to test frequency and voltage control concept); OSMOSE tackled exchanges for grid forming and coordinated control for FACTS and hybrid storage; NEDO, e-badge and FUTURE FLOW addressed balancing market.

Regarding **task 6**, Some projects promote the use of open source software or results (ARROWHEAD, eBADGE, FuturFlow).

Some projects addressed aspects of **task 7** such as CECOVEL (REE) with EV charging management; Future Flow and NEDO with exchanges required for balancing market.

Main gaps to cover this functional objective

Concerning **task 3**, further studies shall be considered including "existing standards".

Regarding **task 6**, open source initiative shall be further developed.

Proposal of evolution for the tasks

Task 2 could be merged with **task 1.**

Task 3 could be:

- merged with **tasks 4, 5, 6, 7** to create one more generic task including all relevant activities on standards;
- merged with **task 2**: Guideline for implementation includes needs for maintening existing standards.

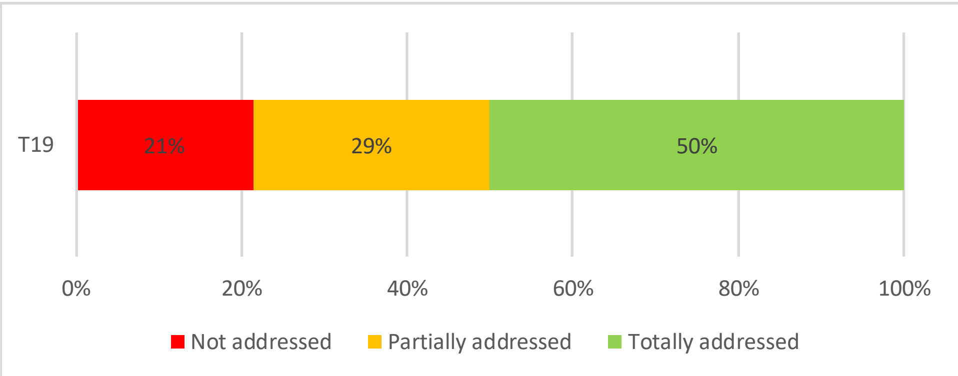
Task 5 could be merged with **task 1.**

Task 6 could be reformulated: "provide results, codes of research project in open source"

General conclusion for the coverage of the functional objective

- Two tasks are totally addressed (**tasks 1 and 2**);
- In terms of evolution for the tasks, the tasks shall be merged or reformulated (see **task 6**).

⇨ **Final coverage of the Functional objective:**



T20 - New technologies, Internet of things

List of tasks included in this functional objective

1. Assess the potential benefits of intensifying the use of IoT in TSO activities
2. Develop an ENTSO-E whitepaper and/or a technical report on the benefits of applying IoT and related tools in the electricity sector
3. Create study and white paper regarding the secure application of IoT technologies through the public internet, taking both risks and privacy into account
4. Develop the interface tools needed to intensify the use of IoT in TSO planning, asset management and operational activities

List of projects considered

The following projects have participated in the survey and claimed to contribute to Functional Objective T20.

FP7/H2020 projects	Other projects
ARROWHEAD GRIDSOL RealValue RESERVE	

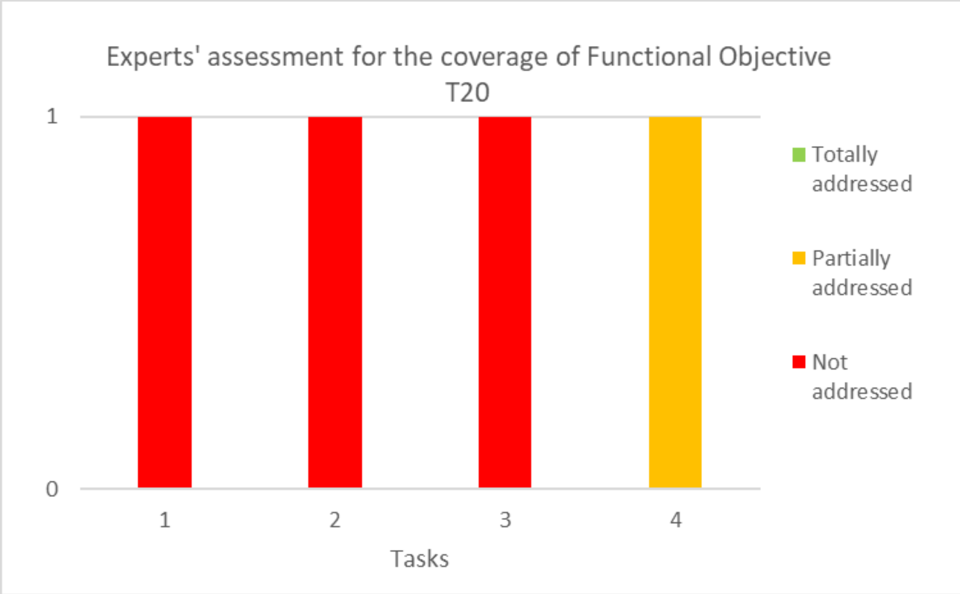
List of experts consulted

The following expert has been consulted. He has provided its expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective T20.

Organisation	Name
ENTSO-E	Ioannis Theologitis

Overview of the coverage of the Functional Objective according to experts' views

Three tasks (**task 1, 2** and **3**) are assessed as not addressed. One task (**task 4** is assessed as partially addressed).



Overall achievements reached under this Functional Objective

There has been some progress provided by ARROWHEAD regarding **task 4** in terms of interface tools to intensify the use of IoT in TSOs' activities.

Main gaps to cover this functional objective

In order to assess the potential benefits of intensifying the use of IoT in TSO activities (**task 1**), pilot solutions exist in the TSO environment; a full-scale implementation and impact assessment is missing. Work is to be done to assess the benefits and identify new services. **Tasks 2 and 3** have not been addressed so far. Regarding **task 4**, more work is needed with regards to interface tools to intensify the use of IoT in TSO planning, asset management and operation.

Proposal of evolution for the tasks

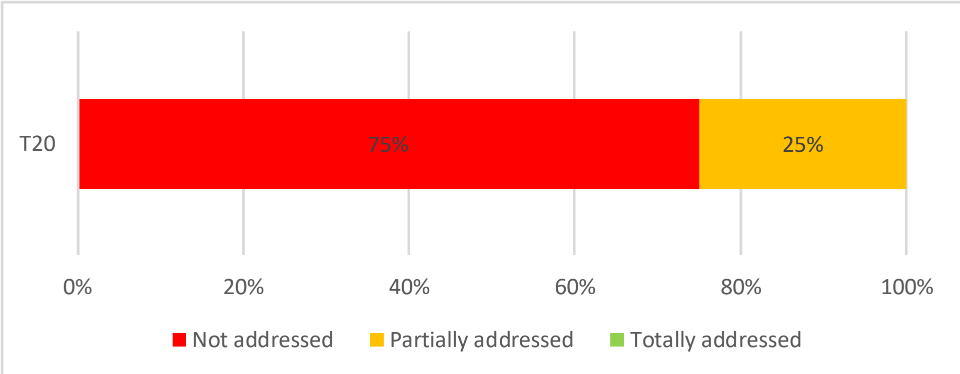
Tasks 1, 2 and 3 might be merged into a single task dealing with both benefits and risks.

Task 4 should be renewed and include market activities.

General conclusion for the coverage of the functional objective

- Three tasks out of four are not addressed;
- In terms of evolution for the tasks: task shall be merged to address similar topics or complemented to include market activities (i.e. **task 4**).

⇨ **Final coverage of the Functional objective:**



T21 - Cybersecurity

List of tasks included in this functional objective

1. Create a strategy for cybersecurity within ENTSO-E
2. Create a best practice guideline for TSO substation and ICT system security design
3. Create a dissemination plan for promoting the strategic initiatives

List of projects considered

The following projects have participated in the survey and claimed to contribute to Functional Objective T21.

FP7/H2020 projects	Other projects
ARROWHEAD FutureFlow SUNSEED	Energy Data Service SECUREGRID

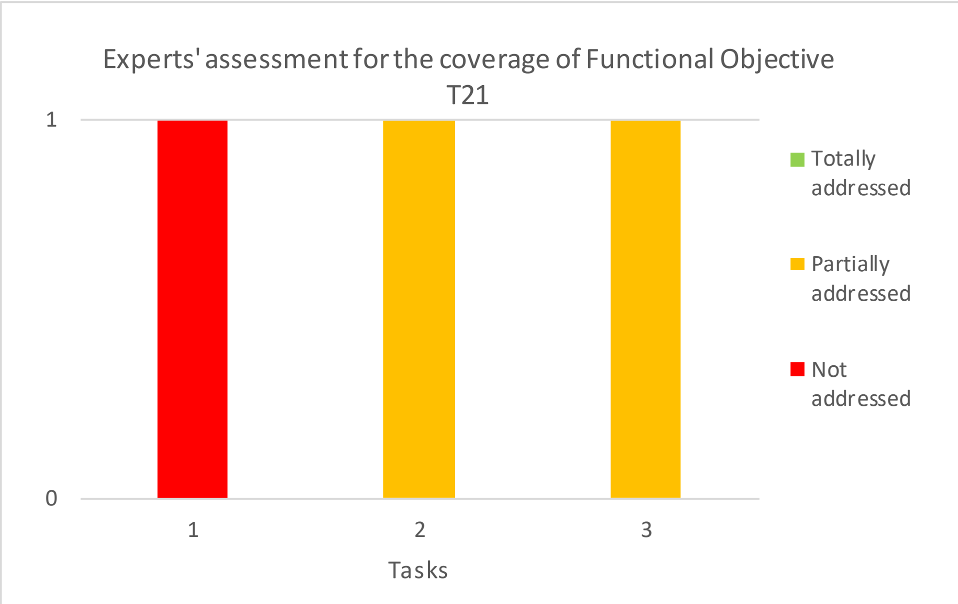
List of experts consulted

The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective T21.

Organisation	Name
ENTSO-E	Ioannis Theologitis

Overview of the coverage of the Functional Objective according to experts' views

Only one expert gave an assessment over the three tasks. Two tasks have been assessed as partially addressed (**tasks 2 and 3**) and one as not addressed (**task 1**).



Overall achievements reached under this Functional Objective

Regarding **task 1**, some attempts and own efforts have been made individually, but not yet within ENTSO-E (all TSOs).

Some developments have been made on **tasks 2 and 3**, like in Energy Data Service and SECUREGRID projects.

Main gaps to cover this functional objective

Regarding **Task 1**, creating a strategy for cybersecurity has not been done so far at ENTSO-E level (involving all TSOs).

A more collective approach is also requested for **tasks 2 and 3**.

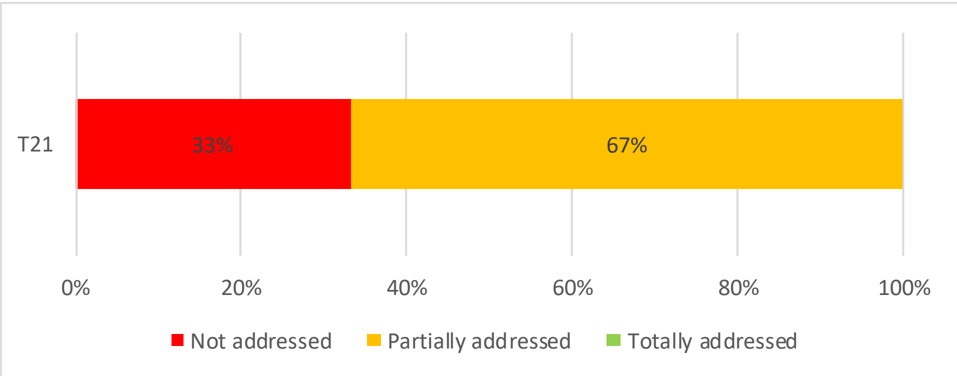
Proposal of evolution for the tasks

Tasks 1, 2 and 3: These tasks could be merged between them, by avoiding "ENTSO-E" and including best practices, strategy and dissemination plan**.**

General conclusion for the coverage of the functional objective

- The three tasks have not been well covered by listed projects and need a more collective approach;
- In terms of evolution for the tasks: the three tasks could be merged.

⇨ **Final coverage of the Functional objective:**



PART 3 – COVERAGE ASSESSMENT FOR THE FUNCTIONAL OBJECTIVES RELATED TO DISTRIBUTION ACTIVITIES

CLUSTER 1 - INTEGRATION OF SMART CUSTOMERS AND BUILDINGS

D1 - Active demand response

List of tasks included in this functional objective

1. Hardware and software solutions for demand aggregation connected with local energy management platform (connecting all market players)
2. Hardware and software solutions for AMI to measure electricity consumption and send time-of use tariffs when needed as well as other applications and services
3. Hardware and software solutions in substation connecting TSOs and DSOs so as to exchange data and allow the provision of AD-based system services from aggregators to TSOs through DSOs
4. Measure the flexibility brought by AD response in operation at a significant spatial scale (several thousands of customers) as well as the economic evaluation and the impact on the grid
5. Demonstrate the use of AD response at a significant spatial scale (several thousands of customers) under stringent constraints (congestions for instance)
6. Demonstrate the ability of DSOs to enable aggregators to provide AD-based system services to TSO through coordinated communications between TSOs and DSOs.
7. Development and implementation of innovative and efficient solution for the exploitation of AD in emergency situations
8. Develop and test devices enabling visualization and control of end-consumers' electricity consumption (for instance in-home displays with control functionalities) using low-cost and end-user friendly technologies (wireless technologies, PLC, smart phones, etc.)
9. Develop and test devices enabling control of end-consumers' equipment such as smart-energy management boxes, smart plugs, smart appliances, interfaces for load control and solutions to communicate with consumers, including the inverters for prosumers
10. Develop and test a communication infrastructure to support the whole system allowing demand aggregation and control (cf. Upgrading of the network) and M2M solutions adapted to the type of services required for the grid
11. Participate in standardization activities so as to make sure that all components of the value chain are interoperable
12. Study possible new incentive mechanisms to promote large scale participation on AD schemes, or explore the possibility of mandatory cutbacks during peak consumption times in order to guarantee grid reliability and stability
13. To carry out sociological studies and develop training and information programs to improve the awareness of end consumers and their understanding of the structure, functioning and the needs of the electricity systems
14. Improvement of the models and simulation algorithms allowing the 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). Market simulators should be able to tackle all time scales: long-term, day-ahead, intraday and real time markets
15. Design adapted incentives (and associated market mechanisms) accounting for the end consumer's acceptance of load flexibility and maximizing their participation in AD-

based schemes (tailor made tariffs such as time-of use/dynamic tariffs and real-time prices and combinations with capacity-based grid tariffs)
16. Study the rebound and deferral effects and provide reliable models to predict them so as to provide DSOs with methods to anticipate their impacts on network operations
17. Methods to assess accurately the amount of shifted energy or modified consumption in AD-response schemes for end-consumers (methods must be transparent and based on data from a trusted third party such as the DSO; methods must also be able to extract the true shifted energy or modified consumption as one component of a load control strategy)
18. Recommendations to enable the integration of active demand in electricity markets (retail and wholesale) with a fair burden sharing and reward for all stakeholders based upon quantified business models
19. Study the potential for cross-border AD-based service provisions (cooperation between connected DSOs)
20. Recommendations to cope with possible commercial and regulatory barriers that could impede the implementation at a pan-European scale of active demand solutions
21. Study compensation mechanisms for mandatory partial consumption cutbacks related to the promotion of grid reliability and stability in peak consumption periods

List of projects considered

The following projects have participated in the survey and claimed to contribute to Functional Objective D1.

FP7/H2020 projects		**Other projects**	
ANYPLACE	INTERFLEX	CLOUDGRID	MODFLEX
ARROWHEAD	RealValue	Dynamo	NEDO
DREAM	SMARTEREMC2	FLEXNETT	NEXUS
eBADGE	SMARTNET	IHSMAG	SMARTPV
EMPOWER	SUNSEED	LIFE Factory Microgrid	Smart Grid Gotland
FLEXCOOP	TILOS		UGRIP
FLEXICIENCY	UPGRID		
GOFLEX	WiseGRID		
inteGRIDy			

List of experts consulted

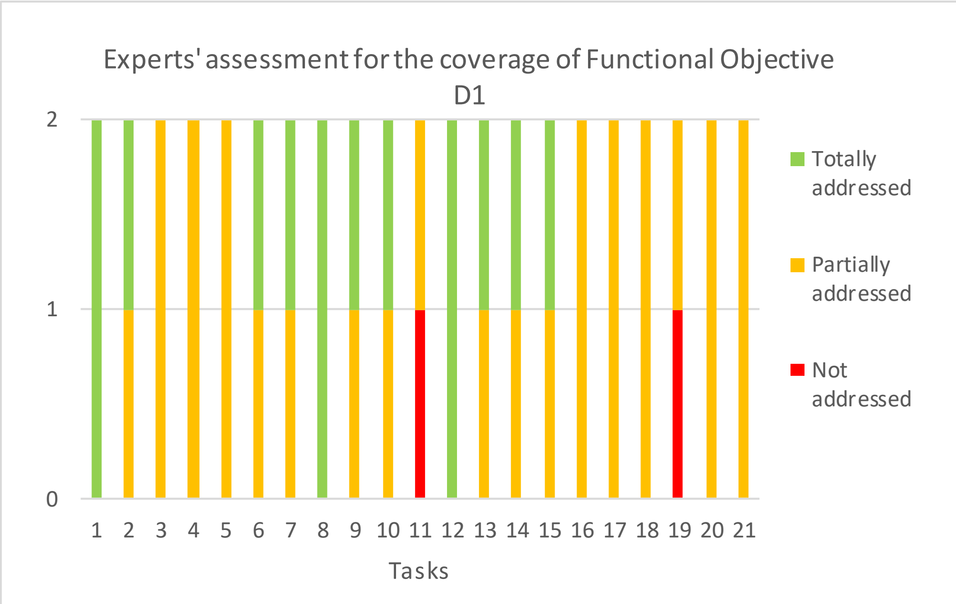
The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective D1.

Organisation	**Name**
DTU	Shi You
IBERDROLA	Jesus Varela

Overview of the coverage of the Functional Objective according to experts' views

Only two tasks are considered as partially addressed or not addressed (**tasks 11 and 19**), while eight tasks are partially addressed or totally addressed (**tasks 2, 6, 7, 9, 10, 13, 14, 15**). Also, eight tasks are considered by all the experts as partially addressed (**tasks 3, 4, 5, 16,**

17, 18, 20, 21). Finally, experts unanimously agreed that three tasks were totally addressed (**tasks 1, 8, 12**).



Overall achievements reached under this Functional Objectiven

Important achievements have been made regarding **task 1**, as many projects led to develop hardware and software solutions for demand aggregation in the last period.

Regarding **task 2**, tools using AMI (Advanced Metering Infrastructure) as the interface between demand response units and demand response managers/aggregators have been developed to increase quality measurement and introduce dynamic tariff, such as time-of-use tariffs for the consumers.

Regarding **task 3**, projects such as ARROWHEAD developed framwork, platform and software solutions to coordinate data exchange among relevant stakeholders, but few solutions have been applied specifically to substations, and still very custom-made.

Considering **task 4**, only a few projects address flexibility at a spatial scale of hundreds of customers, like FLEXICIENCY and RealValue, and they do not provide well supported figures about the impact of Active Demand (AD) on the grid.

Task 5 has the same kind of problematic, with most of the projects developed as small pilots. Few projects with large number of customers don't provide well supported figures about impact of AD on the grid.

Regarding **task 6**, projects such as DREAM and Dynamo developed flexiblity market models/platforms that demonstrate the basic ability of DSOs to enable aggregators to provide services to TSO through coordinated communication between TSOs and DSOs.

Regarding **task 7**, several projects developed solutions through market-based indirect or direct control, with emergency situations being treated as a need of load shedding or energy storage.

Task 8 has been addressed in several projects (ANYPLACE, eBADGE, EMPOWER, FLEXCOOP, InteGRIDy, GRID4EU, ADDRESS) which developed devices for visualization and control of consumption.

Topic linked to **task 9** has been addressed in some projects.

Considering **task 10**, software system enabling the aggregation of demand has been tested in several projects and the telecommunication solution exists.

In **task 11**, standardization activities related to AD are primarly ICT focused in order to meet the needs of system design, controller design, and communication.

Regarding **task 12**, many projects (ANYPLACE, CLOUDGRID, DREAM, Dynamo, eBADGE, EMPOWER, FLEXCOOP, NEDO) address the topic of "incentive mechanisms" and a large review has been done.

Considering **task 13**, projects as Advanced, DREAM, Dynamo, EMPOWER, INTERFLEX, NEDO developed sociological studies or surveys, also other projects not considered in the initial list of projects like Ecogrid[13] and Ecogrid2.0[14].

Regarding **task 14**, several models and simulation algorithms to quantify the impact of AD response on the electricity system are existing.

Considering **task 15**, incentives are often designed as part of AD demonstration based on game theory, market theory sociology or sociology principles, so listed projects have performed different designs targeting different AD-based schemes/services as well as external projects like iPower[15] and Ecogrid[7].

The rebound and deferral effects treated in **task 16** have been addressed by some of the projects.

Regarding **task 17**, software tools and methods have been developed in several projects.

Considering **task 18**, most of the actions considered in the projects have been focused on individual AD technologies such as PV, EV, battery.

Regarding **task 19**, some of the proposed generic market solutions for trading AD-services/integrated AD into grid operation in theory partially covered the cooperation between connected DSOs.

Considering **task 20**, USEF model (provided by Dynamo project) offers a relative generic framework for developing market and regulatory solutions to integrated AD into power system operations. Also, projects not given in the list, such as EnergyLab Nordhavn[16], have developed service-oriented solutions for integrated AD (such as using AD for both power system services and district heating network services within the same market design).

Regarding **task 21**, compensation mechanisms for demand response actions like consumption cutbacks (especially for industrial demand) have been applied in practice for at least decades in many countries through non-cleared bilateral contracts or cleared market-based solutions. In the context of AD-services offered by many different end-users/AD technologies (either through an aggregator or not), new compensations mechanisms are not investigated sufficiently.

Main gaps to cover this functional objective

Regarding **task 1**, future projects must be developped at a large-scale in the next few years to confirm previous results, and designs and evaluation of demand response need to be carried out from an integrated energy perspective (e.g. gas, heat, water) as it can be seen in EnergyLab Nordhavn[10].

Considering **task 2**, new applications to offer services to the final consumer through the AMI system must be explored. Applications considering very fast reaction, such as minute by minute, or second by second control for fast grid services should move on from theory to practice in the next few years.

---

[13] More details on http://www.eu-ecogrid.net/

[14] More details on http://www.ecogrid.dk/en/home_uk

[15] More details on https://ses.jrc.ec.europa.eu/ipower

[16] Danish project, more details on http://www.energylabnordhavn.com/

Standard definition of the services and data to be exchanged needs to be developed to complete **task 3**, as well as a clarification of roles and functions of substations at different voltage levels.

Regarding **task 4**, only credible and replicable figures will lead to know if AD response is a solution applicable everywhere.

Biggest challenge for **task 5** is to develop live field demonstration/application, with high frequency communication and information exchange. Additionally, tests are not usually carried out in areas with real stringent constraints.

Considering **task 6**, some abilities related to complicated interactions between DSOs and TSOs considering large amount of AD have not been fully addressed.

Considering **task 9**, devices for end-consumer to manage energy, especially in summer houses, is not well solved, mainly because they are not yet low-cost and based on telecommunication solutions existing in the customer premises. Also, these devices didn't succeed to provide a real added value for end-consumers.

Regarding **task 10**, Machine to Machine (M2M) solutions adapted to these services are not so well established.

Regarding **task 11**, projects have a lack of automatic and standardized testing solutions for AD controller design, which makes the test and validation of AD controllers often expensive and time consuming.

Task 12 is maybe too wide and difficult to cover. Mandatory cutbacks during peak probably require more regulation changes, than research.

Considering **task 13**, a deeper analysis could be useful to design information programs for end-consumers, and a campaign could be needed to know the point of view and interest of the end-consumer about the "empowerment and user-centered approach" for the electricity system.

Concerning **task 14**, standardized testing and validation approaches (including scenarios, protocols, use cases) are requested, especially regarding applications/research about large-scale AD responses.

Regarding **task 16**, there are few reliable models to predict rebound and deferral effects in the projects covered, and the developed models and methods mainly target a specific portfolio of AD technologies (such as EVs, thermostatically controlled loads). Quality of the results is influenced by the quality of data collected and the design of demonstrations.

Considering **task 17**, even if software tools and methods have been developed in a number of projects given in the list, it's still difficult to have a good estimation of the amount of energy shifted, or modifications on consumption. The assessment can still be improved, for instance being made either for an individual end-user/AD unit or for an aggregated portfolio. It is also an issue since data from a trusted third party can not be guaranteed available.

Regarding **task 18**, AD response programs could be developed for new objectives (e.g. ancilliary services, improved energy efficiency, improved energy economy) and would require different analysis and approaches regarding the challenges of sharing benefits and risk between all stakeholders fairly.

Regarding **task 19**, it is proved that if a solution appears as a result of DSO-to-DSO collaboration, it will produce billing difficulties. So, innovative solutions must be provided considering technical and not technical aspects.

Regarding **task 20**, barriers can vary from case to case depending on which technology, which market and which energy sector.

Regarding **task 21**, current status of demand response policies and compensation mechanisms are summarized by publications from both research institutes/associations at EU level (such as EU JRC and smartEN) and individual researchers. But the success criteria for different compensation mechanisms is not transparent and needs to be studied and developed.

Proposal of evolution for the tasks

Task 1 could be modified to create a new task to develop large-scale aggregation tests.

Task 2 could be re-addressed to focuse only in new services for the final consumer.

Task 3 could be:

- reformulated to highlight the role of substations in AD-based system services from agregators for TSOs through DSOs;
- modified to create a new task to define a standard definition of the services and data to be exchanged (covering the full casuistic, parameters).

Task 4 could be:

- modified to create a new task targeting on very large-scale demand response that involves multiple DSOs and aggregators, multi-operation zones and possibly TSOs with cross-border coordination;
- merged with **tasks 5 and 7**.

Task 5 could be merged with **tasks 4 and 7**.

Task 6 could be reformulated to consider a large-scale real implementation, and a cost benefit analysis of this activity.

Task 7 could be:

- modified to have new approaches, other than aggregators or microgrids: it could be useful to develop the use of AD to support the grid in emergency situations;
- merged with **tasks 4 and 5**.

Task 8 could be deleted as objectives have been reached.

Task 9 could be reformulated to limit the scope to the production and test of devices in which it can be proved that equipment and telecommunications are low-cost and easy to put in service.

Task 10 could be merged with other telecommunication tasks focusing only in the M2M-telecom part of the objective.

Task 11 could be:

- reformulated so the list of standards considered and their coverage for the complete value chain are explicitly mentioned;
- modified to create a new task to develop common test standards for AD.

Task 12 could be deleted as objectives are not enough specific, or merged with **tasks 13 and 15**.

Task 13 could be reformulated to cover also the aspect of knowing the opinion of the end-user about been the center of the system and having an active participation in the grid operation, and merge with **tasks 12 and 15**.

Task 14 could be reformulated to focus the task on the evaluation and validation of existing tools.

Task 15 could be merged with **tasks 12 and 13**.

Task 16 could be modified to create a new task focusing on developing tools to incorporate AD in DSO planning and operation, to serve the needs of different stakeholders (e.g. DSO, TSO, end user, aggregator).

Task 17 could be modified to create a new task to develop 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.

Task 18 could be merged with **task 20**.

Task 19 could be modified to create a new task working on cooperation strategies for connected DSOs to support cross-border AD-based service provisions, considering the difference between DSOs in their technical ability and policy.

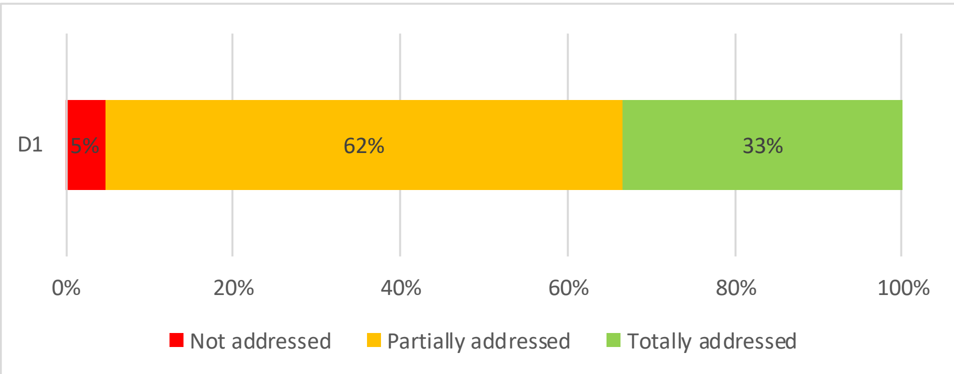
Task 20 could be merged with **tasks 18 and 21**.

Task 21 could be merged with **task 20** and reformulated to proper regulatory treatment and not technical solutions.

General conclusion for the coverage of the functional objective

- Most of the time, experts estimated that tasks were partially addressed due to a lack of large scale experimentations.
- Same issue regarding the tasks that experts have unanimously considered as partially addressed (38%), as there are few experimentations (max. two projects) to approve the existing solutions.
- Main gaps come from only two tasks estimated as partially addressed or not addressed (tasks 11 and 19).
- In terms of evolution for the tasks: nine tasks could be merged with another one and reduce the list of tasks to cover, while six tasks could require to create new tasks; also seven tasks could be re-addressed, reformulated or specified.

⇨ **Final coverage of the Functional objective:**



D2 - Energy efficiency from integration of smart homes and buildings

List of tasks included in this functional objective

1. Network planning and optimization tools linking with urban planning tools so as to optimize the development of the electricity network taking into account energy efficiency policies at the city scale (interaction with other energy network, spatial planning)
2. Advanced ICT infrastructures coupling DSOs and market players so as to estimate customer participation in energy efficiency (cf. D1)
3. Assess the optimal level of intelligence at different spatial scales depending on the city and the existing network topologies (i.e. multilevel operations of the distribution network)
4. Study the benefits of deploying smart secondary substation with an islanding capability to be activated in emergency situations (in the presence of distributed generation and storage)
5. Study the optimal load sharing between primary substations in real time depending on the local constraints at city level
6. 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)
7. Develop and test solutions for direct load control (in close collaboration with telecom operators) via the smart meters and/or the energy boxes installed by service providers
8. Verify that all in-home ICT technologies are fully interoperable (smart appliances, smart meters, energy boxes, monitoring and control devices). A gap analysis of existing standards is also recommended
9. 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
10. Business models for all stakeholders (especially retailers and aggregators) promoting energy efficiency at the end-user level (in relation with AD response, cf. D1)
11. Further study customer acceptance and involvement for energy efficiency measures by taking into account the full environment, i.e. ergonomics (ICT environment), market (price signals), and behavior (rebound effects and arbitrage between comfort and wealth)
12. Propose new regulatory options in a context of lower energy volumes

List of projects considered

The following projects have participated in the survey and claimed to contribute to Functional Objective D2.

FP7/H2020 projects		**Other projects**
ANYPLACE ARROWHEAD eBADGE EMPOWER FLEXCOOP FLEXICIENCY GOFLEX	INTERFLEX NETFFICIENT RealValue SMARTPV SMILE WiseGRID	LIFE Factory Microgrid NEDO NOISEEK

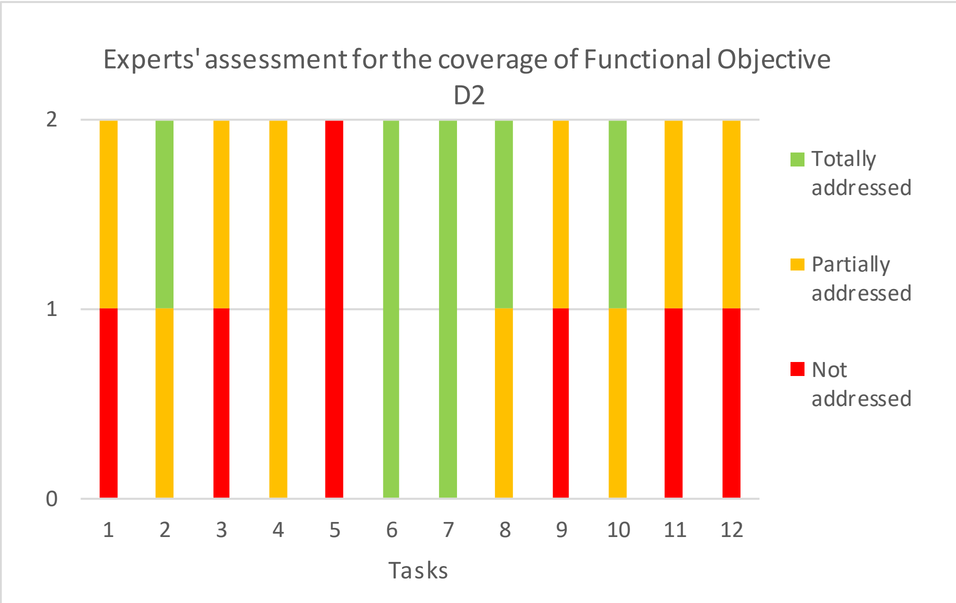
List of experts consulted

The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective D2.

Organisation	Name
EDP Distribuição	Tiago Filipe Simão
ENEA	Viviane Cigoletti

Overview of the coverage of the Functional Objective according to experts' views

Two tasks are considered by all the experts as totally addressed (**tasks 6 and 7**). Three tasks have been judged as totally addressed or partially addressed (**tasks 2, 8, 10**). A large part of the tasks is considered as not addressed or partially addressed (**tasks 1, 3, 9, 11 and 12**), while one tasks is unanimously considered as partially addressed (**task 4**) and another one as not addressed (**task 5**).



Overall achievements reached under this Functional Objective

Considering **task 1**, ongoing projects are partially developping optimization tools and planning, and also methodologies, like in ARROWHEAD, eBADGE or NETFFICIENT projects.

Task 2 is well covered as the estimation of customer participation in energy efficiency is addressed in some of the projects (eBADGE, FLEXCOOP, WiseGRID).

Considering **task 5**, ongoing projects are not covering the optimal load sharing between primary substations in real time. Experts estimated that this task is the one with less addressed projects.

Topics on in-home ICT technologies for friendly environment consumers, linked to **task 6**, has been addressed in most of the projects, including ANYPLACE, eBADGE, EMPOWER, FLEXCOOP, NETFFICIENT, NEDO and WiseGRID.

Regarding **task 7**, direct load control solutions via smart meters and energy boxes have been developed, for instance in EMPOWER or NEDO.

Considering **task 8**, tests have been conducted to verify the in-home ICT technologies interoperability, like in ANYPLACE and FLEXCOOP.

Business models consisting to promote energy efficiency for end-consumers, linked to **task 10**, have been developed in EMPOWER, FLEXCOOP, NEDO and WiseGRID.

Main gaps to cover this functional objective

Regarding **task 1**, projects still have to study the connection with the urban planning tools and the energy efficiency policies in their development.

Projects still need to develop a city scale approach to cover **task 3**.

Considering **task 4**, focus of the study and understanding of the benefits of deploying smart secondary substations with an islanding capability is not directly studied.

Subject of **task 5** is interesting according to the experts, and project developers should propose solutions in the future.

Regarding **task 9**, projects must develop an approach to define the participation of end consumers to the retail market, as previous projects only developed a vision where clients participate to a new flexibility market, which is different from the retail market.

Task 10 has been well covered by existing projects, no further research in the near feature seems to be mandatory for this task.

Considering **task 11**, Future projects should develop new criteria to perfectly value customer acceptance and involvement for energy efficiency, they are still missing evaluation criteria like comfort and wealth.

Regulatory options must be developed in the context of **task 12**, to anticipate lower energy volumes, electric vehicule adoption, distributed renewables, storage. For now, projects miss interrelated trends with lower energy and regulatory options.

Experts estimated that **tasks 2, 6, 7 and 8** has been well covered by existing projects, no further research in the near feature seems to be mandatory for these tasks.

Proposal of evolution for the tasks

Task 1 could be:

- Reformulated without the notion of urban planning tools;
- Merged with **tasks 2 and 3**.

Task 2 could be merged with **tasks 1 and 3**.

Task 3 could be merged with **tasks 1 and 2** to evaluate differences at building/customer level with the city criteria

Task 4 could be reformulated to find the best solutions to address technical, economic and regulatory dimensions of the interaction with local DER necessary for the islanding functioning.

Task 5 requires no specific evolution, task is an interesting subject and need to be covered properly.

Task 9 could be reformulated to clarify how the clients could participate in the retail market.

Task 11 could be reformulated to complete behavioural motivations of the customers.

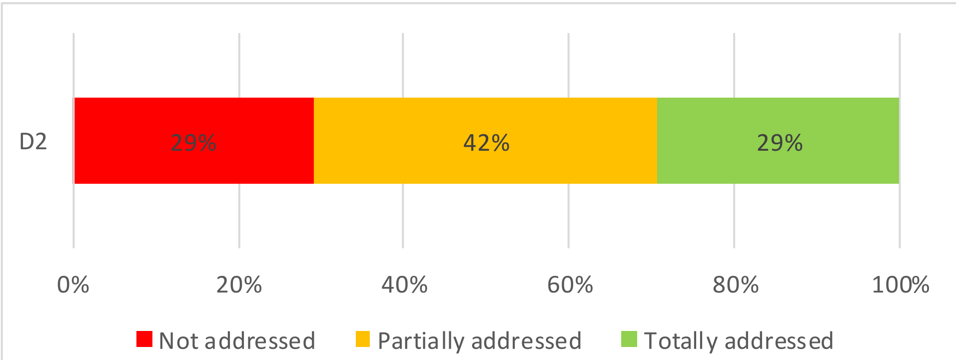
Task 12: No specific evolution, task is an interesting subject and need to be covered properly.

Tasks 6, 7, 8, 10 could be deleted as objectives have been reached.

General conclusion for the coverage of the functional objective

- Half of the tasks has been partially or not addressed, since some projects need to go further in their development and experimenting at large scale.
- Other tasks have been covered by existing projects but still need to improve their concept, as ICT infrastructures coupling DSOs and market players or in-home ICT technologies for instance. However, software solutions for end-consumers and load control via smart meters really progressed as **tasks 6 and 7** are considered as totally addressed.
- In terms of evolution for the tasks: the first three tasks could merge between them, and three other tasks deserve a reformulation according to the experts.

⇨ **Final coverage of the Functional objective:**



CLUSTER 2 - NTEGRATION OF DECENTRALISED GENERATION, DEMAND, STORAGE AND NETWORKS

D3 - DSO integration of small DER

List of tasks included in this functional objective

1. New planning tools so as to provide a complete simulation environment allowing dynamic studies and accounting for all components of LV networks (generation, Final 10-year ETIP SNET RD&I roadmap covering 2017-26108 / 150storage, loads, and topology) including all control systems (especially power electronics)
2. New actuators (e.g. switches) and new sensors (e.g. fault detectors, voltage and current sensors) allowing new control strategies
3. Study and possibly demonstrate the added value of LV DC grids 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. Training of operators so as to adapt to new Network Energy Management platforms.
5. Large scale use of on-load tap changers (and other alternatives) in secondary substations, including the use of reactive power based on voltage control
6. Testing smart meters with capabilities to contribute to almost real-time monitoring in critical zones at critical moments
7. Smart inverters providing grid support functions (active and reactive power control) and therefore allowing innovative control strategies so as to locally optimise balancing
8. 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
9. Accurate forecasting tools (generation and loads) at short-term time scales and local spatial scales
10. Create universal interface devices and protocols to enable DSO information exchanges with DER (mainly for third party owned PV and storage) from different manufacturers and using different technologies
11. Develop new protection schemes able to cope with the increasing penetration of power electronics (inverters)
12. Develop models and the associated simulation software for the evaluation of harmonic distortion and power oscillations in LV network hosting large amount of inverters (power electronics)
13. Develop accurate state estimators based upon the new monitoring devices
14. Develop new tools to detect unwanted electrical islands
15. ICT infrastructure supporting PV integration, i.e. monitoring and control of distributed PV systems
16. Standardization in data exchange protocols/interfaces between all equipment and players, including DSOs
17. Recommendations for valuation of ancillary services brought by distributed PV systems (possibly through self-consumption or when connected to storage devices)
18. Recommendations for the participation of prosumers in electricity markets (including the studies of local energy markets)
19. Incentive schemes and contractual mechanisms for prosumers for short time DER control hand over to DSOs for grid management purposes
20. Recommendations for the access to generation data of prosumers
21. Regulatory framework for temporary use of distributed DER for grid management purposes

List of projects considered

The following projects have participated in the survey and claimed to contribute to Functional Objective D3.

FP7/H2020 projects		Other projects
eBADGE FLEXCOOP GOFLEX inteGRIDy INTERFLEX INTERPLAN NETFFICIENT	PlanGridEV RealValue SHAR-Q SMARTNET SMILE UPGRID WiseGRID	FLEXNETT HEILA NEXUS SAVR Smart Grid Gotland UGRIP

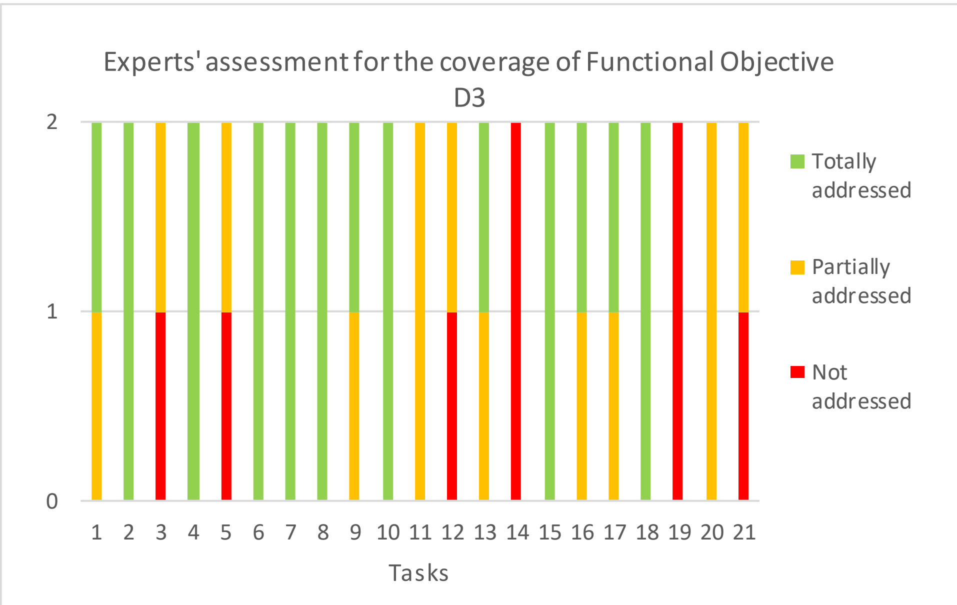
List of experts consulted

The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective D3.

Organisation	Name
HEDNO	Markos Champakis
TRACTEBEL	Frederic Tounquet

Overview of the coverage of the Functional Objective according to experts' views

Over one-third of the tasks are considered as totally addressed (**tasks 2, 4, 6, 7, 8, 10, 15, 18**), and five tasks are totally addressed or partially addressed by the experts (**tasks 1, 9, 13, 16, 17**). Remaining tasks are partially addressed or not addressed (**tasks 3, 5, 12, 21**). Four other topics are unanimously partially addressed (**tasks 11 and 20**) and not addressed (**tasks 14 and 19**).



PLAN. INNOVATE. ENGAGE.

Overall achievements reached under this Functional Objective

Regarding **task 1**, project UGRIP covered totally the topic and ten others partially answered the problematic, including SAVR, eBADGE, FLEXCOOP, INTERPLAN and RealValue.

Considering **task 2**, FLEXCOOP and Smart Grid Gotland developed actuators and sensors.

Concerning **task 4**, SHAR-Q project has totally covered the training subject, while eBADGE, FLEXCOOP and SMILE have partially covered it.

On-load tap changers have been investigated in three projects (eBADGE, SMILE and UPGRID) at small scale for **task 5**.

Smart Grid Gotland and UPGRID totally covered **task 6** and four others addressed it partially (eBADGE, RealValue, SMILE).

Several projects demonstrated that the achievement of the **task 7** was the primary target and has been achieved, including eBADGE and INTERFLEX.

UGRIP and UPGRID projects totally addressed **task 8** while six others partially covered it (eBADGE, NETFFICIENT, PlanGridEV, RealValue, SMILE, WiseGRID).

Task 9 has been totally covered by FLEXCOOP, SHAR-Q, WiseGRID and UPGRID projects.

Depending on the range of Distributed Energy Resources (DER) included, **task 10** has been fully addressed by two projects (SHAR-Q, Smart Grid Gotland).

Regarding **task 11**, approaches developed by several projects (SAVR, SHAR-Q and SMILE) considered inverters but there is still a lack of precise functional objectives.

Considering **task 13**, Smart Grid Gotland and UPGRID showed material proof to reach functional objectives.

Regarding **task 15**, multiple projects (HEILA, NETFFICIENT, SHAR-Q, UGRIP) bring material proofs and associated deliverables.

UGRIP has an important coverage of the **task 16**, while six other projects partially developed the project such as eBADGE, FLEXCOOP or HEILA.

Task 17 has been totally covered by SMARTNET project, while three others partially covered it (NETFFICIENT, SMILE and WiseGRID).

SMARTNET, UGRIP and WiseGRID addressed the key topics linked to **task 18**.

Considering **task 20**, multiple projects have investigated this aspect, mostly from a technology/architecture point of view.

INTERFLEX partially covered the **task 21** with regulatory recommendations provided.

Main gaps to cover this functional objective

Completeness and ability to perform dynamic studies up to LV networks, as part of **task 1**, will first require the development of the associated methodologies and concepts, including power electronics in LV.

Smart meters studied by **task 2** offer new ways of sensing grid flows. Significant efforts have been invested in the frame of the project of translating voltage measurement in reliability indicators that are consistent with existing grid codes and norms (EN50160).

Regarding **task 3**, new actuators and grid components have been developed, but there are still many improvements to be implemented and new elements to be developed.

Coverage of the **task 5** is inadequate because there are some voltage control elements but on-load top changers for secondary substations must be further explored.

Regarding **task 6**, projects with smart meters used as voltage quality sensors are real time monitoring tools and cover the topic.

Considering **task 9**, the local spatial scale part of the topic needs to be clarified.

Regarding **task 11**, project developers should find precise functions/applications to the new protection schemes.

Task 13 is crucial for the functions of modern DMS systems and experts are convinced that it should be studied by more projects. The contribution of other elements (appart from smart meters) must be studied and the state estimation quality must be properly validated.

Task 16 could be perfectly covered if additional material proofs were developed regarding structuring, metering or new services of data exchange protocols/interfaces.

Experts considered that material proofs are missing to estimate that the **task 17** is totally covered.

Regarding **task 19**, "short time" aspect is critical in this topic and should be identifiable in the material proof provided.

Tasks 4, 7, 8, 10, 15 and 18 has been well covered by existing projects, no further research in the near feature seems to be mandatory for these tasks

For **task 21**, temporary aspect has to be further investigated in the listed projects.

Proposal of evolution for the tasks

Task 1 could be:

- reformulated the task as “New planning tools so as to provide a complete simulation environment allowing electromagnetic transient studies for power electronics and accounting for all components of LV networks (generation, Final 10-year ETIP SNET RD&I roadmap covering 2017-26108 / 150storage, loads, and topology)”;
- merged with **tasks 11 and 12**.

Task 3 could be modified to create a new task with the following title: Study and possibly demonstrate the added value of LV DC grids in integrating DER while taking due care for safety.

Task 4 could be deleted as objectives have been reached.

Task 5 could be modified to create a new task with the following title: “Massive use of control technologies in secondary substations and the resulting coordination needs for the system and grid operators”.

Task 9 could be reformulated with the following title: “Accurate forecasting tools (generation and loads) at short-term time scales that are suitable for solving location-based grid constraints”.

Task 11 could be merged with **tasks 1 and 12**.

Task 12 could be merged with **tasks 1 and 13**.

Task 14 could be reformulated with the following title: “Develop new tools to qualify and detect unwanted electrical islands”.

Task 16 could be reformulated with the following title: “Standardization in data exchange protocols/interfaces between all equipment and players that are required for a well functioning market and a safe grid (switching, metering at least)”.

Task 17 could be reformulated with the following title: “Suggestion to differentiate localized and non localized ancillary services (procurement and regulatory framework will be very different).”

Task 19 could be merged with **task 21** (“Regulatory framework for temporary use of distributed DER for grid management purposes”).

Task 20 could be reformulated with the following text: “Recommandations for the secure and privacy-compliant access of generation data of prosumers”.

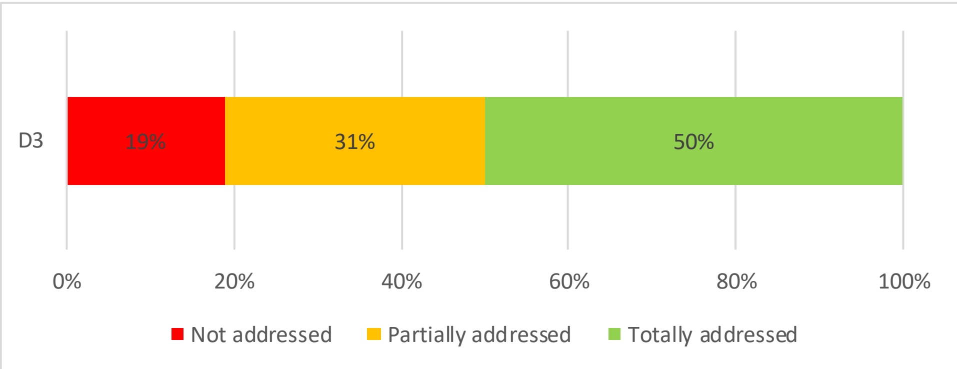
Task 21 could be modified to create a new task: “Define and test regulatory arragements to allow temporary use of distributed DER for grid management purposes”.

Tasks 2, 6, 7, 8, 10, 13, 15, 18 could be deleted as objectives have been reached.

General conclusion for the coverage of the functional objective

- Four tasks suffer from a very low coverage rate as they are estimated as partially or not adressed by the experts, many improvements are requested for them. **Tasks 14 and 19** are considered as not covered at all because no project developed their topic.
- Other tasks beneficiate of a convenient coverage, even if experts estimated that seven tasks are partially addressed and partially or totally addressed due to a lack of projects 100% focus on their topic.
- In terms of evolution for the tasks: over one-third of the tasks can be removed as they have been well covered by existing projects; slight reformulations could be done in six tasks to improve their coverage and three new tasks could be created; regarding tasks with low coverage, experts suggested to create new tasks or merge with others.

⇨ **Final coverage of the Functional objective:**



D4 - System integration of medium DER

List of tasks included in this functional objective

1. New tools for network planning and design including the simulation of active components, RES and control algorithms so as to study cost-effective solutions to increase the hosting capacity of existing grids, deferring reinforcements
2. Training of dispatchers so as to adapt to the new environment (new Energy Management platforms)
3. Network management platforms (with the associated monitoring and control systems) able to interact with all market players (and TSOs if necessary) and with embedded functionalities such as self-healing capabilities for fault management and voltage control
4. Grid support capabilities of smart PV inverters (e.g. voltage regulation, curtailment using reactive/active power control) adapted to distribution network requirements and needs (possibility of centralized direct -and possibly locally automated- communications between DSOs and grid-connected inverters)
5. Grid losses reduction through reactive power compensation provided by DER
6. Fault ride-through support through DER, including islanding operations
7. Develop models and associated simulation software for the study of distribution grids with very low (no) inertia, able to mimic the altered power quality, the modified dynamic behavior of the power system, the possible interactions between the controllers of PE-interfaced generation units (and load)
8. Use the developed models and software to better manage and understand harmonic distortion and power oscillations
9. New actuators (e.g. switches) and new sensors (e.g. fault detectors, voltage and current sensors) allowing new protection and control strategies
10. Network monitoring systems and related ICT infrastructure supporting monitoring and control of DER
11. Standardization in data exchange protocols/interfaces between the DSOs and the TSOs, market players, especially generators
12. Recommendations for valuation of ancillary services brought by DER (e.g. voltage control, active and reactive power control, etc.)
13. New market rules (replacing feed-in tariffs) for the deployment of renewables with proposals for new remuneration schemes
14. Networks codes for DSOs defining the allowed interactions with the different market players during operations

List of projects considered

The following projects have participated in the survey and claimed to contribute to Functional Objective D4.

FP7/H2020 projects	Other projects
INTERFLEX INTERPLAN NETFFICIENT SMARTNET	ADELE HEILA LIFE Factory Microgrid NEXUS WIVE

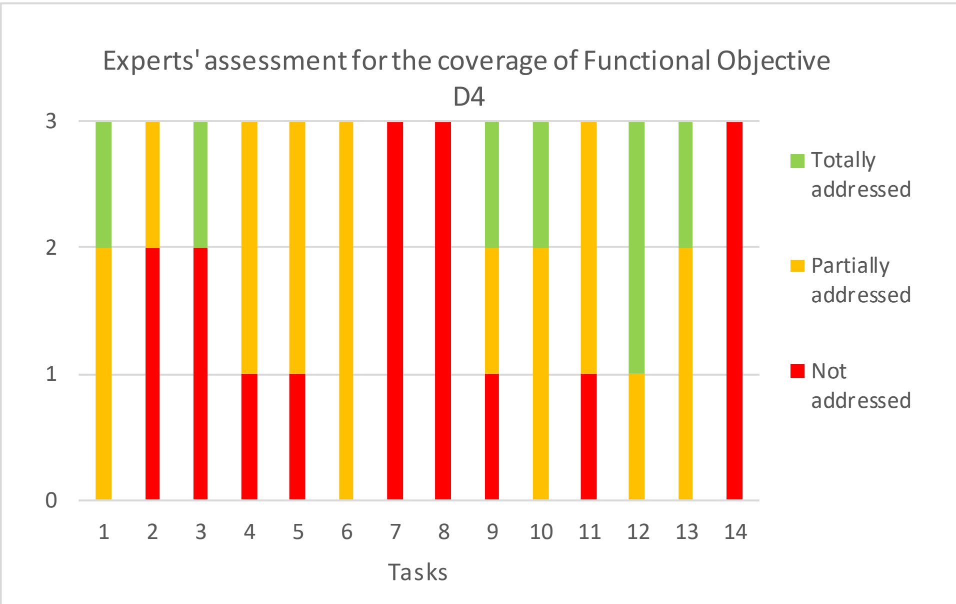
List of experts consulted

The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective D4.

Organisation	Name
CENER	Raquel Garde
ENEL-DISTRIBUZIONE	Gareth Bissel
TRACTEBEL	Niels Leemput

Overview of the coverage of the Functional Objective according to experts' views

Among the list of tasks, four tasks are totally or partially addressed (**tasks 1, 10, 12 and 13**), and one task is considered as partially addressed by all the experts (**task 6**). Four tasks are partially or not addressed (**tasks 2, 4, 5 and 11**) and three tasks are considered as not covered at all by the experts (**tasks 7, 8 and 14**). Finally, two tasks present different assessments: **task 3** has one expert judging the topic as totally addressed and two experts as not addressed; the three experts indicated three different assessments for **task 9**.



Overall achievements reached under this Functional Objective

INTERPLAN project fully addressed the **task 1**. Also, there are others developing tools (softwares) available in the market for these purposes (grid planning, design, operation analysis, etc.) such as PSS (Power System Simulation) or DigSILENT[17].

Considering **task 3**, WIVE fully addressed the subject.

From a technical standpoint, **task 4** has been addressed and solutions are ready for a large-scale deployment. In addition to the projects evaluated, the Puglia Active Network project[18] demonstrated the deployment of these technologies for an entire region of Italy.

[17] More details on https://www.digsilent.de/en/

[18] Italian project funded by the NER 300 program, more details on https://setis.ec.europa.eu/system/files/session_2_2_vincenzo_emma_final.pdf

Task 5 has been addressed on the technical side in LIFE Factory Microgrid and WIVE and reactive power control of Distributed Generation (DG) or Distributed Renewable Energy ource (DRES) (e.g. storage) has been demonstrated in many other projects.

Task 6 has been tested and demonstrated in some of the projects evaluated (LIFE Factory Microgrid and WIVE).

Only the WIVE project covers **task 9**, as other technologies validated in some demonstrators with limited EU coverage.

Task 10 has been demonstrated with a wide coverage in the listed projects.

Considering **task 11**, only the HEILA project addressed partially the standardization topic.

The project SMARTNET particularly addressed ancillary services brought by DER, studied in **task 12**.

Task 13 is totally addressed by SMARTNET and partially by NEXUS.

Main gaps to cover this functional objective

Regarding **task 1**, additional research could be done to increase geographical coverage and address scaling-up of results proposed from the INTERPLAN project. New model softwares for power flow analysis at the distribution level considering DER, storage, DR and control algorithms. Next, demonstration projects / small scale implementation using the new planning approach/tools could be develop and would be related to the existing tasks described (in the ETIP SNET 2017-26 Roadmap) under the Specific Topics Market Design and DSO Regulatory Involvement.

Considering **task 3**, topic must be further developed. It is also important to note that the topic is covered in the H2020 2018 LC-SC3-ES-5-2018-2020 call, and the projects CoordiNet[19] and INTERRFACE[20] will be starting end 2018 / beginning 2019.

Next step for **task 4** consists to address commercial and regulatory aspects. It is important to study if the flexibility of load generation must be contracted based or procured in open-market for instance. Also, some projects about to start from the H2020 ES-5 call will address this topic.

Task 5 has to be studied on commercial and regulatory aspects. From an operational perspective, it is important to know if the objective function of controlling the reactive power will be to maintain a particular voltage profile to correct and reduce losses, or if it is to meet TSO requirements at the primary substation.

If the solutions are using services provided by DER**, Task 6** must study commercial and regulatory aspects of these solutions.

Considering **task 10**, the final solution will depend on the type of system that will be used (e.g. centralised vs decentralised control). The requirements of the ICT infrastructure, especially the communications bandwidth and latancy requirements will depend on the type of functionality of the monitoring and control.

Further coverage and decision on standardisation are requested for **task 11**.

Task 12 needs to be considered at a TSO-DSO level.

Given the diverse nature of distribution systems in **task 13**, this might need further coverage in other regions not already covered. Also, some projects about to start from the H2020 ES-5 call will address this topic.

Proposal of evolution for the tasks

Tasks 1, 7 and 8 could be merged between them.

[19] Led by ENDESA and involving EDSO, more details on https://coordi.net/

[20] Led by European Dynamics and involving ENTSO-E

Task 2 could be:

- merged with **tasks 3** and reformulated as “Development of Energy Management Platforms to manage the Distribution Networks by DSOs taking into consideration the links to TSOs and market (aggregators, retailers, etc.)”;
- reformulated as “Sharing experiences and recommendations for the implementation of new energy management platforms” or “Development of Energy Management Platforms to manage the Distribution Networks by DSOs taking into consideration the links to TSOs and market (aggregators, retailers, etc.)”.

Task 3 could be:

- merged with **tasks 2** and reformulated as “Development of Energy Management Platforms to manage the Distribution Networks by DSOs taking into consideration the links to TSOs and market (aggregators, retailers, etc.)”.

Task 4 could be:

- merged with **tasks 5 and 6** and reformulated as “Analysis of grid support capabilities and benefits provided by DER, storage and DR in the distribution networks and the links between the Distributions and Transmission Networks”;
- reformulated as “Grid support capabilities of smartly controlled loads and renewable energy sources (e.g. voltage regulation, curtailment using reactive/active power control) adapted to distribution network requirements and needs (possibility of centralized direct - and possibly locally automated - communications between DSOs and grid-connected inverters)”.

Task 5 could be:

- merged with **tasks 4 and 6** as specified above;
- reformulated as “Grid impact reduction by intelligently controlling DERs”.

Task 6 could be:

- merged with **tasks 4 and 5** as specified above;
- reformulated as “Grid robustness support through DER, including islanding operations”.

Task 9 could be merged with **tasks 10, 11 and 14** to develop a specific task on ICT and digitalization of distribution (and transmission) networks.

Task 10 could be:

- merged with **tasks 9, 11 and 14** to develop a specific task on ICT and digitalization of distribution (and transmission) networks;
- modified to create a new task linked to the outcome of market/regulatory tasks that could evaluate monitoring and control solutions.

Task 11 could be merged with **tasks 9, 10 and 14** to develop a specific task on ICT and digitalization of distribution (and transmission) networks.

Task 12 could be merged with **task 13** and reformulated as “Analysis of added value of DER, storage and DR in the provision of grid services (balancing, reserves, ancilliary services, etc.) and flexibilty at the distribution level and the impact in the transmission level to define the regulatory framework including the remuneration schemes for new market stakeholders.”

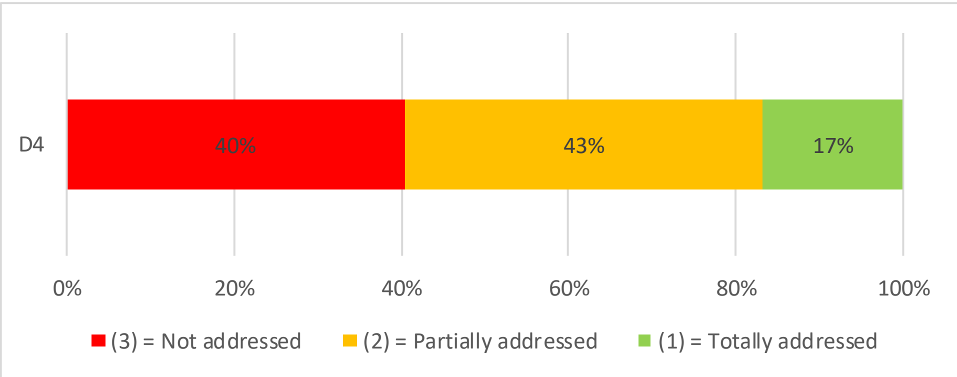
Task 13 could be merged with **task 12** and reformulated as “Analysis of added value of DER, storage and DR in the provision of grid services (balancing, reserves, ancilliary services, etc.) and flexibilty at the distribution level and the impact in the transmission level to define the regulatory framework including the remuneration schemes for new market stakeholders.”

Task 14 could be merged with **tasks 9, 10 and 11** to develop a specific task on ICT and digitalization of distribution (and transmission) networks.

General conclusion for the coverage of the functional objective

- Half of the tasks have been judged as partially or not adressed and not adressed at all. Commercial and regulatory aspects are still missing for some of them, or their topic is not studied by listed projects.
- Four tasks present some improvements as they have been assessed as totally or partially adressed, but still request additional research to define the best solution.
- No task has been unanimously considered as fully addressed.
- In terms of evolution for the tasks: experts proposed merge as a solution for all the tasks, in order to reduce the number of tasks to 5. Tasks would be more focused on a global subject

⇨ **Final coverage of the Functional objective:**



D5 - Integration of storage in network management

List of tasks included in this functional objective

1. Make sure that all tools used by network operators (operation, asset management, planning) account for the possibilities offered by storage, e.g. dynamic network simulation tools embedding the simulation of storage systems with active control algorithms, or planning tools accounting for the possibilities offered by storage when extending and/or refurbishing the network (e.g. deferred investments)
2. Study the added value brought by storage in MV/LV networks for the control of power flows, voltage profiles, power quality, as well as islanding and micro-grid applications, including black start capabilities
3. Study the optimal spatial distribution of storage systems (especially for BESS systems) accounting for all constraints of the power system
4. Study the integration of hybrid storage devices so as to have a Virtual Storage Power Plant (VSPP) fulfilling different functionalities. For instance, hybrid systems such as a flywheel-BESS-supercapacitor could help to cover wider ranges of functionalities.
5. Study the use of automated local thermal energy storage devices and local automated BESS (consumer level) by market players (aggregators, retailers) so as to provide system services for network operators
6. At building level, investigate the inertia of thermal loads so as to better grasp the dynamics of the coupled energy system (electricity-heat-buildings)
7. Investigate new innovative control strategies to better control PV and storage systems so as to locally optimise balancing (LV networks)
8. Demonstrations of integrated design of the storage devices, e.g. joint design between battery manufacturers and power electronics providers, in order to optimise costs with the maximum coverage in terms of functionalities
9. Storage in electricity networks for transportation (e.g. tramways) located in substations to provide system services to DSOs
10. Study on the integration of hybrid storage devices and multi-BESS systems
11. Further study the use of “second-life” automotive battery for stationary applications: battery pack selection, BMS as well as costs of BoS to be considered
12. Study large scale centralized energy storage (e.g. thermal or chemical) for energy supply security over weeks to months
13. Increase the integration of storage in cogeneration units in order to improve their flexibility
14. Simulation tools to better appraise the cycling profiles associated to the envisaged applications and business models, which in turn, allow to estimate accurately the lifespan (and the failure modes) of the storage device
15. Duty cycle standards so as to give undisputed performance certifications for market players using storage devices to provide system services
16. RD&I activities to understand the complex system dynamics of power systems with large power electronics penetration (power electronics interfaces for storage integration)
17. Study the development of self-consumption policies involving local storage so as to better control its effects on the stability of the power system
18. ICT infrastructure for connecting (monitoring and possibly remote controlling by different actors) all storage devices to the network and/or energy and/or customers management platforms of the different actors (DSOs, retailers, aggregators, etc.)
19. Standardized communication protocols between storage devices and inverters, but also between storage devices and remote storage management platforms to meet requirements from network operators, retailers and aggregators (including cybersecurity).

20. Develop a common coordination mechanism/platform/interface between storage providers and grid operators (allowing aggregation) in order to better control the power system and maximise social welfare
21. CBA 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)
22. Multiservice business models for storage integration with a focus on the valuation and remuneration schemes of the system services brought by storage (regulations and market mechanisms to be studied and implemented)
23. Investigate the use of dynamic pricing as a tool to trigger participation of storage in flexibility markets
24. Study and demonstrate the integration of Power2heat solutions for balancing and storage; with a focus on dynamic compensation between heat and electricity
25. Study the social acceptance of storage related to potential security and environmental impacts
26. Investigate the needs for new regulatory mechanisms addressing storage ownership and operations for markets players and DSOs

List of projects considered

The following projects have participated in the survey and claimed to contribute to Functional Objective D5.

FP7/H2020 projects		Other projects	
ELSA GOFLEX inteGRIDy INTERFLEX INTERPLAN RealValue SHAR-Q	SMILE TILOS WiseGRID	ADELE ADOSA CLOUDGRID FLEXNETT HEILA LIFE Factory Microgrid LIFE ZAESS PROTTES RENOVAGAS	Smart Grid Gotland SMART GRID BATTERY STORAGE PROJECT SMARTER NETWORK STENSEA STORAGE STORES UGRIP

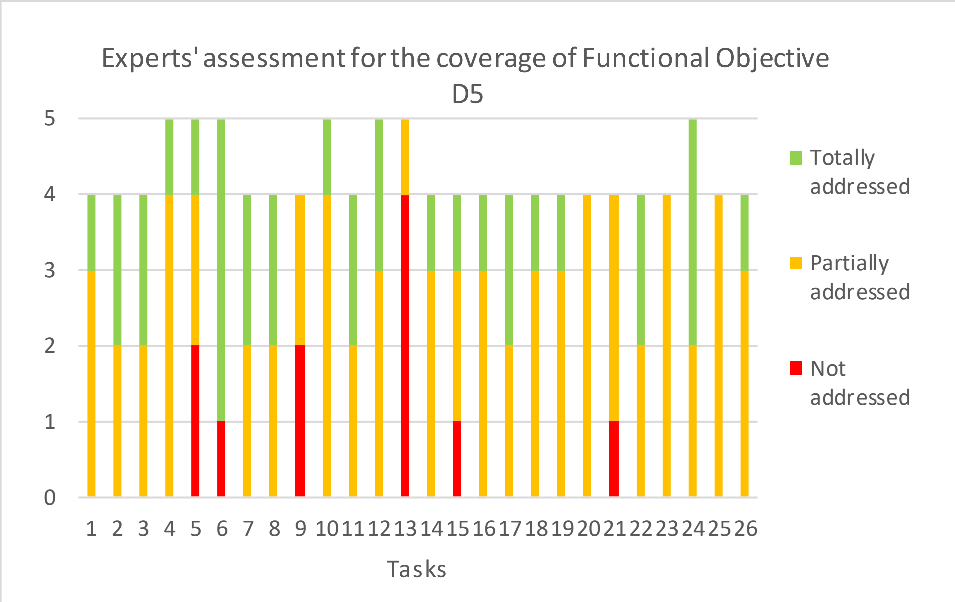
List of experts consulted

The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective D5.

Organisation	Name
CENER	Raquel Garde
CIRCE	Carlos Arsuaga
ENEL	Gareth Bissel
TECNALIA	Eduardo García Quincoces
VITO	Grietus Mulder

Overview of the coverage of the Functional Objective according to experts' views

Some topics have not been enough investigated by the listed projects: **tasks 9, 13 and 21** are considered as partially or not addressed by the experts. Seventeen tasks have been assessed as totally or partially covered by the experts. Three tasks are unanimously considered as totally addressed (**tasks 20, 23 and 25**). Three tasks have different assessments, either considered as totally, partial or not at all covered (**tasks 5 and 15**), or totally or not addressed (**task 6**).



CIRCE expert partially answered to the list of tasks, this explains that **tasks 4, 5, 6, 10, 12, 13 and 24** received five assessments instead of four as the other tasks.

Overall achievements reached under this Functional Objective

INTERPLAN and Smart Network Storage show a good coverage of the **task 1**. Some demonstration projects finished or ongoing have results that indirectly contribute to task, providing methodologies rather than tools.

Task 2 is fully addressed by projects such as FLEXNETT, SMART GRID BATTERY STORAGE PROJECT PROTTES, Smart Grid Gotland, STORES, TILOS or UGRIP. Some specific functions may not be totally analysed, as black start, but from an overall perspective it is considered as fully addressed.

INTERFLEX, LIFE Factory Microgrid, SMILE or STORES have given few direct contributions to the **task 3**, but none of them systematically analyse the optimal spatial distribution of storage. Other scientific and technical studies analyse the optimal spatial distribution of BESS.

ADOSA and SMILE projects studied the **task 4** from a technological point of view (eg. increase of storage functionalities) and from the grid viewpoint (better stability, frequency control, etc.).

Regarding **task 5**, several projects have addressed the coordinated operation of BESS and thermal storage at customer levels and some other projects developed IT platforms for distributed assets control by an aggregator or a DSO.

Among listed projects, INTERFLEX provided the main elements that address **task 6**, but final results are expected in 2019. There are also other projects or products not mentioned in this assessment focused on the optimal operation of building inertia according to electricity spot markets but taking into consideration also the confort for the bulding users.

Several projects fully addressed the optimization of local energy balancing through PV+Storage mentioned in **task 7**, such as Smart Grid Gotland, and even consider the possibility of offering ancillary services to the DSO. There are also external projects that contributed to the task like PVSITES[21] and BIPVBOOST[22].

Several projects addressing **task 8** provided great solutions either based on second life batteries or other technologies (submarine pump hydro or CAES).

Regarding **task 9** external projects are developing solutions, such as Ferrolinera[23] and Hesop[24].

ELSA project fully addressed the **task 11** and included several demonstrators of different characteristics. The project is considered as a very relevant contribution to this task.

Considering **task 12**, ADELE project totally addressed the topic with the development of CAES technology, which is mechanical storage. Also, CASES and H2 fully focused on the design, analysis and demonstration of large-scale technologies through proof of concepts.

Regarding **task 14**, Some projects like ADOSA developed simulations tools that analyse the operation and estimates the lifespan of the storage systems, but it is unclear how lifespan evaluation has been included in the projects.

Other activities as the new standards contributed to the coverage of **task 15**. Recently some standards and guidelines have been proposed with standardized duty cycles for several applications (frequency regulation, load levelling, etc), as IEC 61427-2 of August 2015 or the Energy storage test manual published by EPRI 2016. Few battery manufacturers applied these standardized duty cycles or has included the results in the battery datasheets.

Even if STORES and SMILE projects cover properly the **task 16**, they don't address the complexity of the topic. Smart Grid Gotland could have been in the reference according to experts.

Regarding **task 17**, topic is well studied in Smart Grid Gotland and in STORES. Some other studies related to this field exist, such as OPTIBAT[25]. Results of the studies may vary a lot depending on the applied methodology, storage control strategy and the grid.

Platforms and multi carrier hubs developed in projects HEILA and inteGRIDy provide solutions for the **task 18**.

Regarding **task 19**, projects such as UGRIP and SHAR-Q proposed and implemented standarized and/or open communications protocols between elements and operators to allow an interoperability between elements and agents. Several standard communications protocols and architectures at different level have recently included storage assets, as for example SunSpect[26] and IEC61850. Many of the specific solutions projects were based on the use of these standards.

Considering **task 20**, several projects focused on the development of IT tools for facilitating and enhancing the aggregation and control of distributed assets, but the issue of social welfare is not explicitly mentioned.

ELSA, SMART GRID BATTERY STORAGE PROJECT PROTTES, SMARTER NETWORK STORAGE or STORES proposed, designed and analysed multiservice business models studied in **task 22**.

[21] More details on https://www.pvsites.eu/

[22] More details on https://www.bipvboost.eu/

[23] Spanish project, developed by ADIF, uses a stationary battery to recovered from regenerative braking for later charge of EV, more details on http://www.adif.es/en_US/comunicacion_y_prensa/fichas_de_actualidad/ficha_actualidad_00072.shtml

[24] French project, developed by ALSTOM, reversible substation for electric transport that can include an storage system and hence provide services upstream (DSO) or downstream (tramway), more details on https://www.alstom.com/hesop-saving-energy-and-costs-single-solution

[25] Optimal Location of Electrical Energy Storage Systems based on Batteries, more details on https://www.ehu.eus/documents/6621474/8854442/OPTIBAT+Presentation/5f0f43d9-77b1-8c20-5c5b-4881916c38a2

[26] Project about communications between inverter and storage, more details on https://sunspec.org/

Regarding **task 23**, IT platforms have been developed to control storage system (agreggated or not), offering grid services according to real time market prices. Dynamic pricing has been studied in more detail for the electricity retail market but not so much for flexibility markets.

Study and recommendations from INTERFLEX project considered the controllability of both Power2heat systems and thermal storage studied in **task 24**.

Considering **task 25**, few studies are related to the social acceptance of storage focused on security and environmental impacts, and many times the studies focused in a specific demonstration facility. Social acceptance of storage assets may vary a lot from one location to another due not only to the storage technology/facility characteristics but also to many external factors.

SMART GRID BATTERY STORAGE PROJECT PROTTES, SMARTER NETWORK STORAGE or STORES addressed **task 26**, and a lot of proposal of changes were made in different studies to facilitate the participation of storage or unless to avoid barriers.

Main gaps to cover this functional objective

Regarding **task 1**, project analysis was constructed on a demo basis with one technology tested under specific conditions, but the impact on the grid has to be further studied and focused on some demonstration projects finished or ongoing.

Considering **task 2**, regulatory framework is a fundamental aspect for the development of storage systems, and it is identified in many cases as a barrier. Changes are required to adapt them to extend storage assets. A validation on real system with larger EU coverage is requested, as an economic evaluation of alternative options for given functionalities.

Regarding **task 3**, next steps would be to define how the storage systems could be operated, and how the regulation and market would be set up. For now, projects only consider very specific case studies and analyse specific BESS operation strategies (not all the potential benefits storage).

Projects consider distributed storage systems jointly operated in **task 4**, and they should study hybrid systems in a next step.

Main gap for **task 5** is the regulation, to promote the implementation of these type of schemes.

A more detailed analysis could be done for projects concerned by **task 6**, to assess whether different cases have been covered (depending on types of buildigns, heating systems, etc.).

A specific definition of market/regulatory framework is needed to cover **task 7**.

Even if current projects are going in the right way, the contribution of current projects is not enough to fully address **task 8** as new technologies could arise and need development and demonstration.

Additionnal developments must be done regarding **task 10** to progress in the integration of hybrid storage devices.

The low penetration of EV in ELSA has not permitted to fully evaluate second-life concept and its associated technologies and business models studied in **task 11**.

Task 14 still requests to analyse in detail the effect of cycling on the storage system life, which at the same time highly varies with the technology and working conditions.

Regarding **task 16**, there is still much RD&I activity to be developed to understand coupling between systems, resonance problems and others, in systems with high penetration of power electronic devices.

Related to **task 17** and what is also commented for other tasks (as the one related to regulation), it would be interesting to create a consolidated result/document with the policies recommendations to enhance the impact on the main stakeholder.

Considering **task 18**, regulatory aspects are fundamental for further development and demonstration of these technologies. Next step must focus on the implementation and level integration of the systems.

Task 19 still has gaps in its analysis, due to the low penetration of storage that does not allow a standard solution for interoperability. Cybersecurity aspect must be further developed and implemented.

Regarding **task 21**, profitable business cases are very dependent on the regulation and market of the country so more cases or CBA tools are necessary to identify the best scenarios and develop tools with a systematic analysis and comparison of storage against other possibilities.

Further effort should be made to cover **task 22**, as there are only few utility scale projects participating in the European electricity markets which are the main niche markets related to frequency regulation services in UK and Germany (where there has already some multiservice demonstrations).

Further effort should be made to contribute to the coverage of **task 24** including system level integration, and it would be interesting to include a similar task for Power2gas.

Regarding **task 26**, it is important to collect recommendations from projects and studies in a coordinated way and propose a consolidated document with the main conclusions and results.

Proposal of evolution for the tasks

Task 1 could be merged with **tasks 2, 3, 16 and 17** and reformulate as “Study of the grid including storage and any other new technology by power flow analysis (static and dynamic) to quantify the potential benefits from storage (even in small self-consumption plants), to identify the storage needs and proper emplacements and taking into account grid investement deferrals”.

Task 2 could be:

- merged with **tasks 1, 3, 16 and 17** and reformulate as specified above;
- modified to create a new task to study the remuneration schemes design for storage.

Task 3 could be:

- merged with **tasks 1, 2, 16 and 17** and reformulate as specified above;
- merged with **task 9**;
- reformulated to include methodology/guidelines development with some real case studies for the most common scenarios in Europe, including islands.

Task 4 could be:

- merged with **task 10** to have a new task devoted to the analysis of hybrid storage technologies from the technology viewpoint: design of real hybrids in one asset, internal management system, new technical functionalities, etc;
- merged with **task 5** to highlight the interest of multicarrier hybrid storage systems. The new task must include the analysis of the economical benefit of operating an hybrid storage system in comparison to a single storage unit, and the studies should be made according to current market conditions.

Task 5 could be:

- merged with **tasks 6 and 24** to create a task dedicated to the synergies between heat and electricity;
- merged with **task 4** to highlight the interest of multicarrier hybrid storage systems. The new task must include the analysis of the economical benefit of operating an hybrid storage system in comparison to a single storage unit, and the studies should be made according to current market conditions.

Task 6 could be merged with **tasks 5 and 24** to create a task dedicated to the synergies between heat and electricity.

Task 7 could be reformulated as “Development of new 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”.

Task 8 could be:

- modified to create a new task with similar definition for both consumer and utility scale battery systems and with Integrated PV+Storage systems;
- merged with **task 11** and reformulated in a new task as “Study and demonstration of new integrated energy storage technologies, including 2nd life batteries, to optimise the design, performance and cost taking into account power electronics and Balance of Plant”.

Task 9 could be:

- merged with **task 22** and specify the option of transportation+DSO services;
- merged with **task 3**;
- reformulated as “Analysis and demonstration of using storage systems in electricity networks for transportation (e.g. tramways, buses) located in substations to provide system services to DSOs and study of the impact in the local grid in terms of stability, power quality and investment deferrals”.

Task 10 could be:

- merged with **task 4** to have a new task devoted to the analysis of hybrid storage technologies from the technology viewpoint: design of real hybrids in one asset, internal management system, new technical functionalities, etc;
- merged with **tasks 4 and 5** and specifically mention the need of a cost benefit analysis.

Task 11 could be:

- merged with **task 8** and reformulated in a new task as “Study and demonstration of new integrated energy storage technologies, including 2nd life batteries, to optimise the design, performance and cost taking into account power electronics and Balance of Plant”;
- modified to create a new task that should include cost/benefit analysis, experimental/demonstration assessment of the lifetime of the 2nd life battery, cost analysis (refurbishing, replacing, recycling).

Task 12 shall be maintained and further studied.

Task 13 could be:

- reformulated as “Analysis and demonstration of energy storage systems integrated with conventional power generators such as cogeneration, hydropower, thermal plants to increase their flexibility and improve operation”;
- Modified to create a new task named “Improve the effectiveness and load hours of combined heat and power units by introducing heat or electricity storage”.

Task 14 could be:

- reformulated to specify the accuracy/detail required for storage life modelling and indicating standard cycling profiles (e.g. IEC 61427-2);
- reformulated as “Simulation tools to better appraise the cycling profiles associated with the envisaged applications and business models. The mathematical fundaments including ageing must be open. This will, in turn, allow an accurate estimation of the lifespan of the storage system (and the failure modes) and profitability”;
- modified to create a new task named “Development of open source tools for selection and sizing of energy storage systems (also hybrid technologies) according to the applications (or services to provide) and their standarised 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";
- merged with **task 15**, to define and measure the technical characteristics and performance of the energy storage influences the values. Users need benchmarking data to calculate profitability depending on the technology and the duty cycle (application).

Task 15 could be:

- merged with **task 14**, as as specified above;
- modified to create a new task for the verification of existing system service cycles on their validity and usefulness;
- reformulated to focus in adapting duty cycles to European cases and comparing the performance of certain batteries under those cycles.

Task 16 could be:

- merged with **tasks 1, 2, 3 and 17** as specified above;
- create a new task that integrates the experience on virtual rotating mass in power converters, including an assessment on the change in reliability and efficiency;
- create a new task with similar objectives but including modelling and simulation activity and specifying the main problems to be analysed.

Task 17 could be:

- merged with **tasks 1, 2, 3 and 16** and reformulate as specified above;
- reformulated to include the possibility of a consolidated and coordinated policies recommendations.

Task 18 could be merged with **task 19** to create a new task related to ICT and digitalization of distribution (and transmission) networks. It requires new hardware, software (tools, platforms) and harmonised standards and codes to ensure interoperability and proper communications.

Task 19 could be:

- merged with **task 18** as specified above;
- merged with **task 20**;
- reformulated to specify protocols to be used.

Task 20 could be:

- merged with **task 19**;
- merged with **task 7**;
- reformulated as "Develop a common coordination mechanism/platform/interface between storage providers and grid operators (allowing aggregation) in order to better control the power system".

Task 21 could be:

- reformulated to include the pertinent Cost Benefit Analysis (CBA) and Life Cycle Analysis (LCA) assessment in each storage project at initial stage;
- merged with **tasks 22, 23, 25 and 26** to create a new task "Study and development of multiservice business models and/or CBA tools for storage integration with a focus on the valuation and remuneration schemes of the system services brought by storage paying special attention to the flexibility services and taking also into consideration and quantifying the social and environmental benefits. Investigate and propose regulations and market mechanisms to be implemented for new stakeholders (aggregators, storage owners, DSOs, etc.)".

Task 22 could be:

- reformulated to include the study of the regulatory framework (still unclear for storage and with substantial changes from one country to another);

- merged with **tasks 21, 23, 25 and 26** as specified above.

Task 23 could be:

- merged with **tasks 21, 22, 25 and 26** as specified above;
- merged with **task 24**.

Task 24 could be merged with **task 5 and 6** to create a task dedicated to the synergies between heat and electricity.

Task 25 could be:

- merged with **tasks 21, 22, 23 and 26** as specified above;
- create a new task to focus on life cycle, environmental and security assessment guidelines development and applications to new projects, so that to be able to compare result based on similar methodologies (guidelines are necessary as there is still a regulatory and standardization mesh related to both smale and utility scale storage systems).

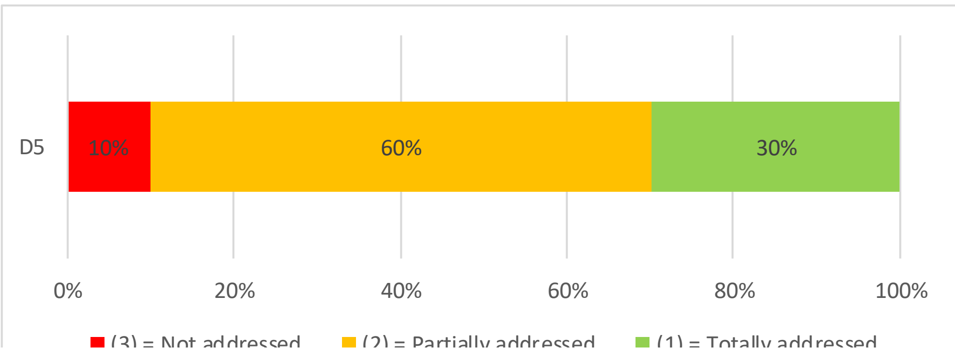
Task 26 could be:

- modified to create a new task including the need of coordinating results and creating a consolidated proposal of regulatory changes;
- merged with **tasks 21, 22, 23 and 25** to create a new task as specified above.

General conclusion for the coverage of the functional objective

- Over the twenty-six tasks, a large part (seventeen tasks) has been assessed as totally or partially addressed by the experts. More experience are requested by the experts who judged the tasks as partially addressed, as they evaluated that specific functions are still missing. Also, many external projects were quoted by the experts as part of the task coverage.
- Three projects are considered as partially or not addressed (**tasks 9, 13, 21**) as only few developments have been made in the last period.
- No task has been unanimously considered as fully addressed by the experts.
- In terms of evolution for the tasks: many proposals of merge have been made by the experts to reduce the list and increase the focus on major topic. Also some creation of new tasks have been suggested to add specific points.

⇨ **Final coverage of the Functional objective:**



D6 - Infrastructure to host EV/PHEV – Electrification of transport

List of tasks included in this functional objective

1. 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 are needed for the assessment)
2. Simulation tools to assess the steady state and dynamic impacts in operation (especially power quality and voltage profiles) of a large roll-out of EVs on the distribution grids
3. Energy management in transport electricity network located with storage solutions in substations (connecting with the local DSO) to provide system services to DSOs (e.g. with a storage device recuperating the braking energy of tramways)
4. Development of smart (and controllable) EV charging/battery swapping infrastructures accounting for energy availability, network constraints and electricity prices
5. Further develop V2G technology solutions and assess the true costs of implementation and the benefits
6. To ensure interoperability with the future EVs (with a focus fast, very fast, and inductive recharge technologies)
7. Optimization tools for power flow calculation able to simulate the power electronics embedded in charging station (recharge) and EVs (V2G application), including the control systems (both hardware and software)
8. Forecasting tools accounting for customer behavior so as to predict EV charging loads.
9. Development of centralized/distributed remote management systems 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
10. Interface the remote management system with the Energy management platforms (cf. D4 for instance)
11. Creation of a common marketplace in order to provide roaming services for EV charging services
12. Tariff schemes and incentives to promote optimized charging and facilitate customer engagement
13. Demand response: market mechanisms for V2G applications
14. Regulatory issues regarding market design and network regulation to efficiently integrate electric vehicles in electricity grids (system services)

List of projects considered

The following projects have participated in the survey and claimed to contribute to Functional Objective D6.

FP7/H2020 projects		Other projects
INTERFLEX PlanGridEV SHAR-Q	UPGRID WiseGRID	FLEXNETT HEILA LIFE Factory Microgrid

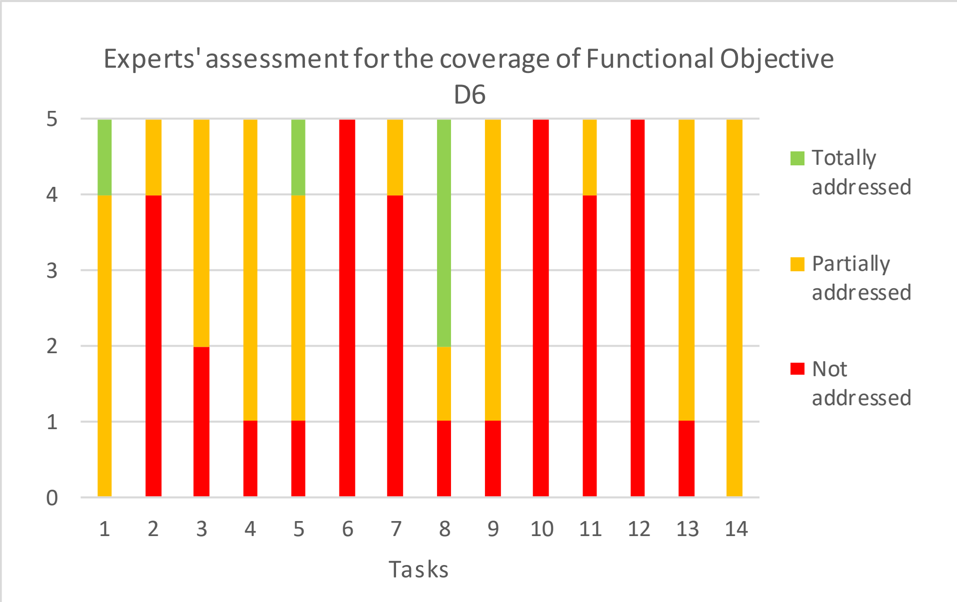
List of experts consulted

The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective D6.

Organisation	Name
CIRCE	Carlos Arsuaga
ENEL	Gareth Bissel
TRACTEBEL	Niels Leemput
VITO	Grietus Mulder
VTT	Seppo Hänninen

Overview of the coverage of the Functional Objective according to experts' views

Most of the tasks are considered either as not addressed or partially addressed (**tasks 2, 3, 4, 7, 9, 11, 13**) and only partially addressed (**task 14**). **Tasks 6, 10 and 12** are unanimously considered as not addressed at all by the four experts. **Tasks 5 and 8** have been subjected to diverging assessments.



Overall achievements reached under this Functional Objective

Network modelling and optimization tools for planning in the presence of massive integration of EVs, linked with **task 1**, have been developed by at least two projects (PlanGridEV, WiseGRID).

Task 2 dealing with simulation tools to assess the steady state and dynamic impacts of a large roll-out of EVs on the distribution grids has been only slightly touched by the PlanGridEV project.

SHAR-Q project has very little coverage with the **task 3** as it only aims to establish an interoperability network that connects the capacities of the neighbourhood, but with no links to transportations.

Regarding **task 4**, the WiseGRID demonstrates the Fast EV charging station with V2G capability. Fast EV charging station will make possible to use EV as dynamic distributed storage devices, feeding electricity stored in their batteries back into the system when needed. The SHAR-Q project aims to establish an interoperability network that connects the capacities of the neighbourhooding and wide regional Renewable Energy Source (RES) + Energy Storage System (ESS) ecosystems into a collaboration framework.

SHAR-Q, together with LIFE Factory Microgrid also contributed to **task 5** about the development of V2G technology solutions.

WiseEVP and UPGRID addressed **task 8**, services relying on advanced algorithms to monitor the LV grid based on information provided by smart meters, existing systems and remote terminal units, but with no real applications to EVs.

HEILA and SHAR-Q projects contributed to **task 9** by developing energy management algorithms enabling smart grids integration of EV charging infrastructures.

By developing the WiseVEP-tool used by EVSE operators and Electric Vehicle (EV) fleet managers in order to optimize the activities related with smart charging and discharging of the EVs and reduce energy billing, the WiseGRID project contributes to partially cover **task 13**. By means of this platform they will be able to plan and control the charging/discharging schedule of all EVs of the fleet. This tool is possible to use for demand response activities.

Regulatory issues regarding market design and network regulation to efficiently integrate electric vehicles in electricity grids (**task 14**) have been addressed by INTERFLEX, WiseGRID and PlanGridEV.

Main gaps to cover this functional objective

Additionnal developments specific to Electric Vehicle sector are requested for **task 8**.

Concrete hardware implementation must be the next step, with regards to **task 9**, consisting in developing centralized/distributed remote management systems enabling smart grids integration of EV charging infrastructures.

More work regarding regulatory issues requested to efficiently integrate electric vehicles in electricity grids (**task 14**).

Proposal of evolution for the tasks

Task 1 could be:

- merged with **tasks 2 and 7** and reformulate as: "Modelling and optimization tools for network simulation, planning, operation and asset management in the presence of massive integration of EVs";
- reformulated as “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 are needed for the assessment)”.

Task 2 could be:

- merged with **tasks 1 and 7** and reformulate as specified above;
- reformulated as “Simulation tools to assess the operational impacts of a large roll-out of EVs on the distribution grids”.

Task 3 could be reformulated as “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)”.

Task 4 could be:

- merged with **task 6** and reformulated as “Development of smart (and controllable) EV charging and battery swapping infrastructures accounting their network integration and interoperability with future EVs (with fast, very fast, and inductive recharge technologies)";

- merged with **tasks 3 and 4** to include all the characteristics desirable for the "charging station of the future";
- reformulated as “Development of smart (and controllable) EV charging infrastructures accounting for energy availability, network constraints and electricity prices”.

Task 5 could be merged with **task 13** and reformulated as "Busines models and market mechanisms for ancillary services provided by EVs and cost benefit analysis (CBA) of EV charging infrastructures”.

Task 6 could be:

- merged with **task 4** and reformulated as specified above;
- merged with **tasks 10 and 11**.

Task 7 could be:

- merged with **task 4** and reformulate as “Development of smart (and controllable) EV charging and battery swapping infrastructures accounting their network integration and interoperability with future EVs (with fast, very fast, and inductive recharge technologies)";
- merged with **tasks 1 and 2** and reformulate as specified above ;
- reformulated as “Optimization tools for power flow calculation able to simulate the distribution grid impact of EVs”.

Task 8: No specific indications for this task.

Task 9 could be:

- merged with **task 10** and create those two tasks: "Remote management of EV charging power infrastructure and its interface to energy managemant system" and “Management of business and billing actions";
- reformulated as “Development of centralized/distributed remote management 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”.

Task 10 could be:

- merged with **task 10** and create two tasks as specified above;
- merged with **tasks 6 and 11**.

Task 11 could be merged with **tasks 6 and 10**.

Task 12 could be merged with **task 14** and reformulated as “Regulatory issues regarding market design, tariff schemes, incentives and network regulation for EV integration”.

Task 13 could be:

- merged with **task 5** and reformulated as "Busines models and market mechanisms for ancillary services provided by EVs and cost benefit analysis (CBA) of EV charging infrastructures”;
- reformulated as “Demand response: technology for facilitating V2G applications“.

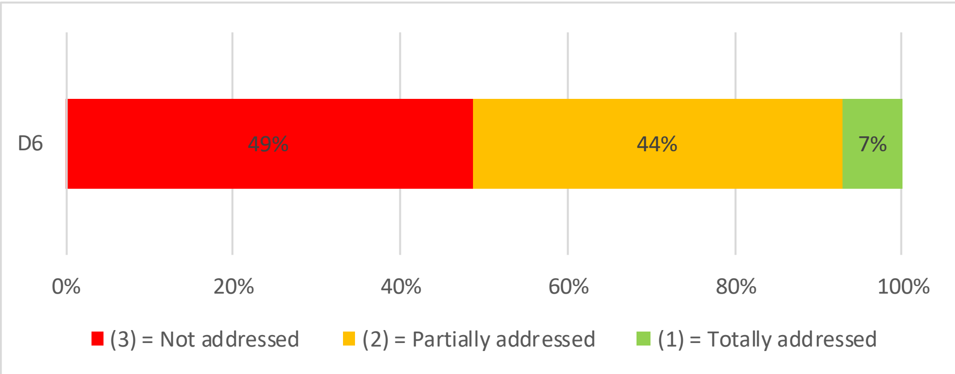
Task 14 could be:

- merged with **task 12** and reformulated as specified above;
- reformulated as “Identifying regulatory barriers, market design principles, and network regulation measures to efficiently integrate electric vehicles in electricity grids (system services)”.

General conclusion for the coverage of the functional objective

- A large majority of the tasks have been addressed as partially or not adressed, and not adressed at all by the experts.
- Other tasks are mostly partially addressed or they have different assessments (**tasks 5 and 8**).
- In terms of evolution for the tasks: Additionnal researches need to be made on this functionnal objectives. Different mergers are suggested for each tasks, as some reformulations.

⇨ **Final coverage of the Functional objective:**



D7 – Integration with other energy networks (heating and cooling, gas, etc.)

List of tasks included in this functional objective

1. Methods and simulation tools to provide a coupled analysis of the dynamics (including steady state analysis) of the coupled system (heat and cooling, gas, electricity networks with an extension to water -waste and drinking- and public transport networks in urban areas)
2. Large-scale demonstrations of successful integration of power to gas technologies in the energy system (including coupling with local fuel supply)
3. Develop methodologies and tools for joint planning and operation of different energy systems (electricity, gas, heat)
4. System services (balancing) brought by heating (and cooling) network operators in case of low (or negative) residual loads when producing and storing thermal energy.
5. System services (balancing) brought by gas network operators in case of low (or negative) residual loads when producing and storing chemical energy
6. System services (balancing) brought by drinking water and network operators in case of low (or negative) residual loads
7. System services (balancing) brought by individual electrical boiler in case of low (or negative) residual loads when producing and storing thermal energy; the connection, control and management of CHPs connected to district heating networks, including those coordinated as "virtual power plants", so as to provide flexibility
8. 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
9. Security assessment for the whole energy system in case of outages in the electricity network (e.g. electric pumps in the district heating and cooling networks, or in the drinking and waste water networks, as well as electric compressors and control equipment in the gas network)
10. Specify and assess the costs of the ICT infrastructure needed to connect all market and regulated players of the energy system
11. Demonstrate the 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.
12. Market simulators coupling the electricity, gas and heat markets, building upon flow-based methods and simulation tools
13. Market design (and the associated regulatory framework) for e.g. thermal storage for participation in electricity and heating markets

List of projects considered

The following projects have participated in the survey and claimed to contribute to Functional Objective D7.

FP7/H2020 projects	Other projects
INTERFLEX RealValue	RENOVAGAS

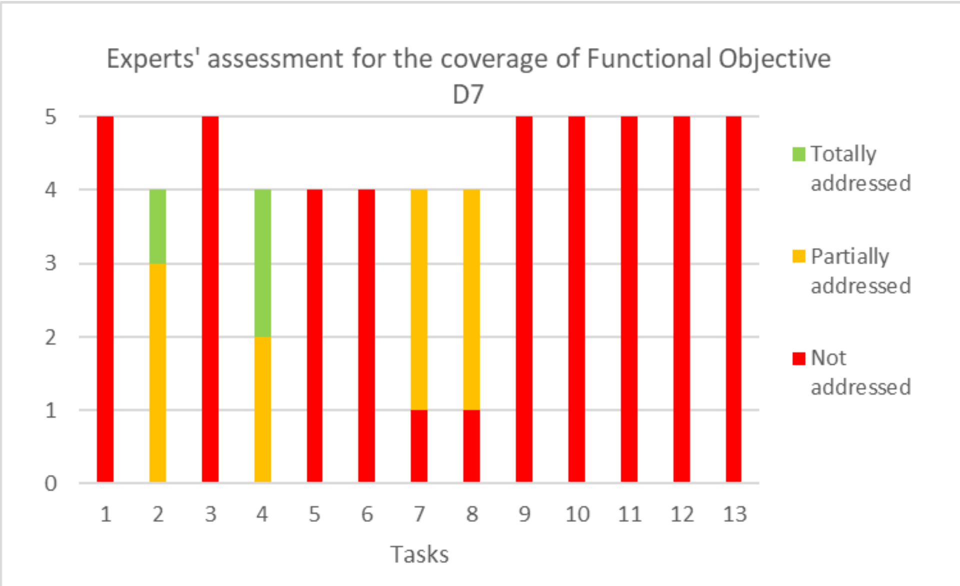
List of experts consulted

The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective D7.

Organisation	Name
CEZ Distribuce	Vaclav Janoušek
CIRCE	Carlos Arsuaga
GNF	John Chamberlain
TRACTEBEL	Niels Leemput
VITO	Dirk Vanhoudt

Overview of the coverage of the Functional Objective according to experts' views

Most of the tasks are unanimously assessed as not addressed by the projects considered (**tasks 1, 3, 5, 6, 9, 10, 11, 12, 13**). **Tasks 7 and 8** are considered partially addressed by some experts. **Tasks 2 and 4** are considered partially to totally addressed.



Amongst the five experts consulted, one has provided an input considering only the aspects of the Natural Gas Grid Sector, and the Interflex project for his assessment. From this angle, none of the tasks were considered covered or relevant explaining the fact that some tasks have only 4 inputs.

Overall achievements reached under this Functional Objective

The RENOVAGAS Project includes a demonstration of a P2G prototype contributing to **task 2** (integration of large-scale power to gas technologies).

System services brought by heating and cooling networks (**task 4**) have been developed by INTERFLEX and RealValue. In particular, within the Swedish pilot of INTERFLEX, the balancing services that a district heating network can provide to the system operator have been tested in a real environment. RealValue has also contributed to **task 7** with service systems brought by individual electrical boilers.

Task 8 is touched by INTERFLEX and RealValue, but for INTERFLEX the CHP management is done at building level, the CHP not being connected to a district heating. Moreover, the STORM-project also demonstrated the management of CHP for balancing purposes in the electric grid (www.storm-dhc.eu).

Main gaps to cover this functional objective

Task 2 about the integration of large-scale power to gas technologies still need to be addressed, since only small-scale prototypes have been developed so far.[27]

Work is still needed regarding system services brought by heating and cooling networks (**task 4**). Even though this is a proven concept which is in use in several countries, for EU wide implementation more clarity is needed in terms of guidelines and standards in particular concerning the role of district heating operator in the energy market. In addition, there is a need to define how DSO can control an activation of flexibility and evaluate its impact on the grid.

More generally, the dynamics of coupled energy systems (heat and cooling, gas, electricity networks with an extension to water -waste and drinking- and public transport networks in urban areas) haven't been studied so far. Simulation tools, joint planning methodologies, security assessment for the whole energy system, haven't been developed yet.

From the Natural gas grid point of view: none of the tasks are covered. Further projects are required regarding end user appliances and high levels of H2. P2G simplistic tools may be required to determine the quantity of H2 (to be added to the group and quantity of excess of renewable electricity to be stored). Also, it might be required to assess potential of long term storage between electricity and NG grid.

Proposal of evolution for the tasks

Tasks 1, 3 and 12 could be merged with simulation tools addressing both planning and operation of the coupled energy systems.

Tasks 4 to 7 could be merged. In particular, a task only for electric boilers seems too specific. The flexibility potential should be studied at household / building / industry level rather than at equipment level. Furthermore, it might be interesting to also include other forms of power-to-heat technology, like heat pumps, heat pump boilers and others.[28]

Other tasks might be brought together with ones addressing similar topics within other clusters and functional objectives: **task 9** about security, **task 10** about ICT infrastructure, **task 13** related to market design.

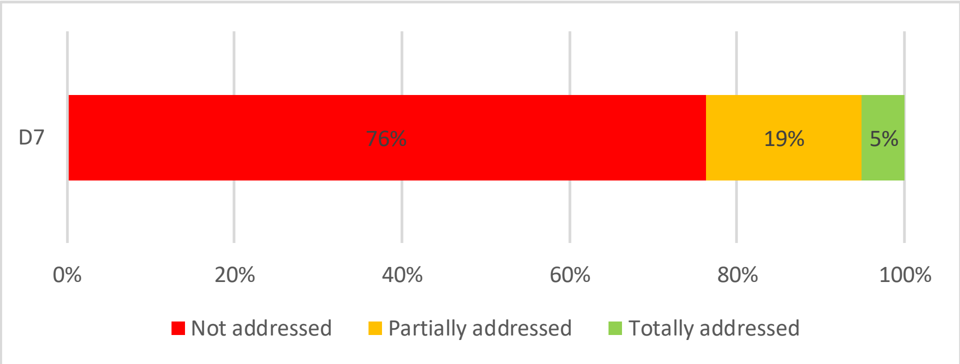
[27] The projects considered for D7 do not include the STORE&GO project which has developed prototypes up to 1 MW.

[28] This is also studied in the FHP project (fhp-h2020.eu)

General conclusion for the coverage of the functional objective

- The main gaps are clearly identified regarding integration of large-scale power to gas technologies and system services brought by heating and cooling networks .
- On a whole, nine tasks out of thirteen are considered as not addressed at all.
- In terms of evolution for the tasks: a general simplification of the structure and merging of common topics is strongly recommended.

⇨ **Final coverage of the Functional objective:**



D14 – Integration of flexible decentralised thermal power generation

List of tasks included in this functional objective

1. To further increase the rate at which a thermal generation unit can increase or decrease its output (load following capability)
2. To improve start-up/shut-down time and ramp rates
3. To further reduce the minimum load at which a thermal generation unit can reliably operate
4. To improve performances (efficiency and emissions) at partial loads
5. To increase the clean fuel flexibility of thermal power plants, to be able to use different sources of fuels (mixing and switching)
6. To adapt waste heat recovery solutions (ORC, etc.) to the flexibility challenge so that energy efficiency improvements do not lead to a reduced flexibility
7. To decouple the use of heat and power (e.g. via buffers, storage, power-to-heat, power-to-gas, power-to-fuel)
8. To better integrate existing and future units in the grid/energy system
9. To demonstrate integration of technologies with high electrical efficiency that can use hydrogen, biomass and biofuels
10. To optimise the connection, control and management of the units, including those coordinated as "virtual power plants", and providing flexibility to the power system.
11. To demonstrate contribution of small and micro-CHP to “virtual power plant” configurations
12. To integrate small-scale and micro-CHPs, energy storage and demand response for optimal balancing of supply and demand, while maintaining high efficiency operation of the CHP system
13. To demonstrate the complementarity between small- and micro-CHP installations and heat pumps at the district level

List of projects considered

Three projects have participated in the survey and claimed to contribute to Functional Objective D14.

FP7/H2020 projects	Other projects
Flexturbine INTERFLEX TURBO-REFLEX	

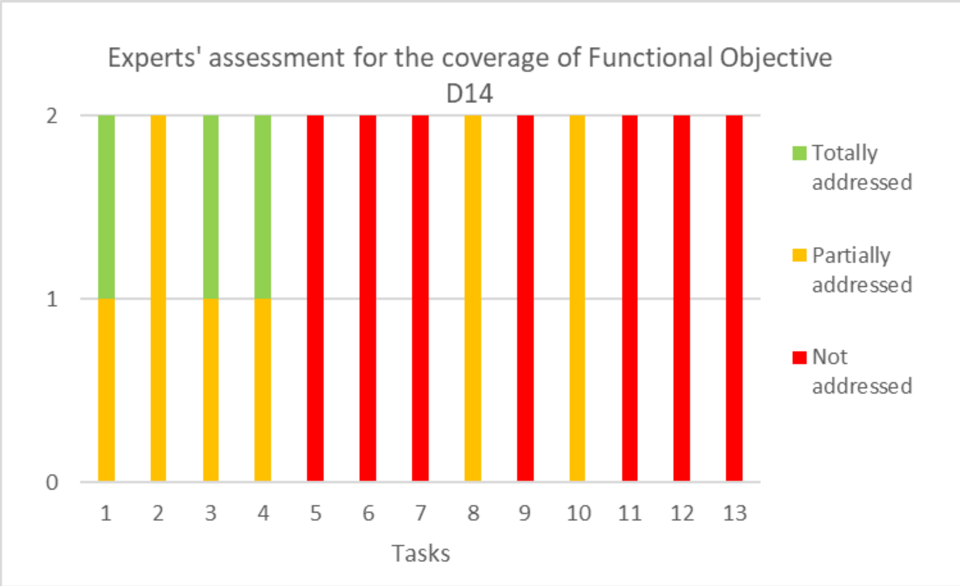
List of experts consulted

The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective D14.

Organisation	Name
CIRCE	Carlos Arsuaga
EDPD	Tiago Filipe Simão

Overview of the coverage of the Functional Objective according to experts' views

The experts consulted considered that seven out of thirteen tasks are not addressed (**tasks 5, 6, 7, 9, 11, 12, 13**). Three tasks are unanimously assessed as partially addressed (**tasks 2, 8 and 10**) and 3 tasks are considered both partially and totally addressed (**tasks 1, 3 and 4**).



Overall achievements reached under this Functional Objective

Both TURBO-REFLEX and Flexturbine will develop new solutions (materials, components and Software) to make power plants more flexible in connection with **tasks 1 and 2**, mainly with the doubling of the ramp rate to allow thermal plants to better follow the load requirements of the system in TURBO-REFLEX and innovative seals and bearings designs for steam and gas turbines for Flexturbine.

Moreover, the design of a local flexibility market as proposed by INTERFLEX provides the grounds for more efficient use of flexibilities provided by thermal generation in multi-energy service systems. This indirectly contributes to **Tasks 1 and 2** of the functional objective.

TURBO-REFLEX and Flexturbine proposed solution to improve the efficiency of power plants when not working in base load in connection with **task 3**. It is particularly relevant with TURBO-REFLEX's KER2 focusing on increasing low load capability of existing plants.

INTERFLEX contributed to decouple the use of heat and power (**Task 7**). The Swedish demos in Simris and Malmö focused on the interaction between thermal and electricity grids, while converting excess renewable power into heat for residential and commercial customers. The business use cases included the operation of a large heat pump and the use of thermal inertia as a significant and cost-efficient source of flexibility.

The projects TURBO-REFLEX and Flexturbine claimed significant efficiency improvements and cost reductions when plant is operating at partial loads (in connection with **task 4**). They will even increase their suitability to provide energy and services to the grid in a high RES peneteration scenario (in line with **task 8**).

Task 10 is partially addressed by the INTERFLEX project. The main innovation of the Use Cases dedicated to the management of flexibilities was to use simultaneously flexibilities from multiple sources, to trade them locally on a "Local flexibility market", and to control them remotely (for instance through the German demo "Smart Grid Hub"). The management of conventional power plants is optimized (from an economic and operational perspective) in TURBO-REFLEX and Flexturbine.

Main gaps to cover this functional objective

The optimization of control and management of distributed units coordinated as "virtual power plants" is not addressed (**task 10**).

The integration of technologies with high electrical efficiency that can use hydrogen, biomass and biofuels (**task 9**) is also untouched so far. The use of small-scale and micro-CHPs for balancing purposes, VPPs or in complementarity heat pumps at district level still needs to be demonstrated (**tasks 11, 12, 13**).

Proposal of evolution for the tasks

Several tasks should be merged (**tasks 1 and 2**, **tasks 3 and 4, and tasks 10, 11, 12, 13**) or reformulated.

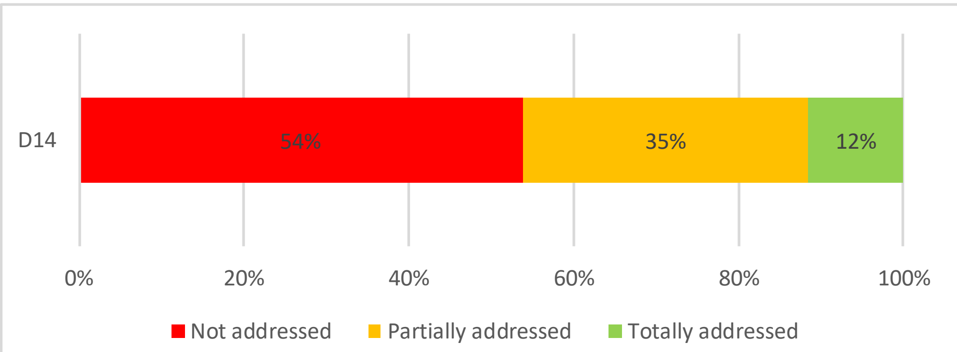
Task 8 could be reformulated since its coverage is mainly a matter of interpretation of what is exactly meant by better integrating existing and future units in the grid/energy system. Certainly, the development of enhanced DSO and aggregator platforms contribute to this task but the technical aspects of the integration of existing and new units in the energy system should also be considered.

Tasks 5, 6, 7, 9, 11, 12, 13 could be kept as they are since they are not addressed.

General conclusion for the coverage of the functional objective

- On a whole, six out of thirteen tasks are assessed as not addressed;
- In terms of gaps, solutions to create and operate Virtual Power Plants are not addressed and shall be further investigated.
- In terms of evolution for the tasks, in general the tasks shall be clarified and merge, especially the tasks in line with the VPP concept (**tasks 10, 11, 12, 13**).

⇨ **Final coverage of the Functional objective:**



CLUSTER 3 - NETWORK OPERATIONS

D8 - Monitoring and control of LV network

List of tasks included in this functional objective

1. Develop protection schemes as well as remote control systems for two-way power flows (communication with smart PV inverters) and network switches
2. Study automatic control concepts and determine the most cost-effective automation level (semi-automated versus fully automated LV network) with data protection and cyber security approaches, adapted protection schemes and use of decentralized storage
3. Operational scheduling tools for optimal grid configuration based on day-ahead forecasting and real network data to maximize (DER penetration, EV penetration, etc.) or minimize (network congestions, network losses, reverse power flows to TSO, etc.) given objective functions
4. LV and MV monitoring combined with forecast algorithms to display the actual availability of network capacity with respect to its standard value, providing a clear knowledge of the network performance, facilitating the calculation of the set points for their controls and also providing a clear view of grid assets loading
5. Definitions of information to be exchanged between the MV and LV levels regarding coordinated reactive power management
6. Investigate and evaluate how the communication structure for AMM could be used as an information channel and for load control. Load control can be used to inform certain loads, on the basis of network capacity, when it is appropriate to increase or decrease consumption. This could also involve pricing
7. New control architecture for optimized operation
8. New algorithms to identify system topology
9. Information model aggregation (using IEC 61850)
10. Data protection and cyber security methodologies
11. Communication infrastructure supporting integration
12. Communication interfaces on secondary substation level
13. Develop accurate frequency and voltage measurement devices (with a focus on the costs and the ease of integration)
14. Use AMM as an operational component in the automation architecture
15. Use new systems to 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
16. Recommendations on market rules and mechanisms for provision of ancillary services, islanding modes of operation
17. Coordination between technical grid control and market-based power balancing (e.g. technical virtual power plants vs. market based virtual power plant)

List of projects considered

Nineteen projects have participated in the survey and claimed to contribute to Functional Objective D8.

FP7/H2020 projects		Other projects	
DREAM	SHAR-Q	SAVR	REDACTIVA
GOFLEX	SMARTNET	FLEXNETT	SINAPSE
INTERFLEX	UPGRID	HEILA	Smart Grid Gotland
NETFFICIENT	WiseGRID	LVM	STORES
RESERVE		NEDO	UGRIP

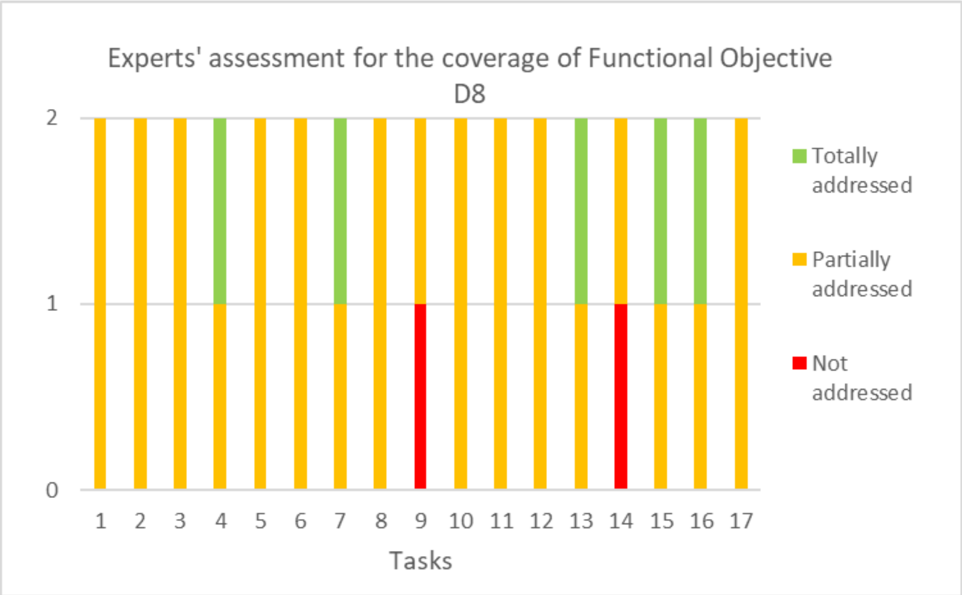
List of experts consulted

The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective D8.

Organisation	Name
IBERDROLA	Jesus Varela
TECNALIA	Eduardo Garcia Quincoces

Overview of the coverage of the Functional Objective according to experts' views

The two experts consulted unanimously consider most of the tasks as partially addressed (**tasks 1, 2, 3, 5, 6, 8, 10, 11, 12, 17**). **Tasks 9 and 14** generated different opinions (partially and not addressed) and **tasks 4, 7, 13, 15 and 16** are assessed both partially and totally addressed.



Overall achievements reached under this Functional Objective

Regarding **task 1**, REDACTIVA project developed solutions to avoid undesired islanding operation protecting the system and Power electronics to reduce/avoid ferro-resonance.

RESERVE works on a new approach "Virtual Output Impedance". Smart GridGotland deals with grid faults and algorithms to protect the grid while optimizing the needed curtailment of wind production. Moreover, UPGRID has developed protection schemes based on real-time monitoring of LV grid and connected elements.

Concerning **task 2,** the DREAM, LVM, STORes and UGrip projects were related to the topic and treat some automation concepts applied to a wide set of aspects (DER, microgrids, storage and customers participation).

Concerning **task 3,** INTERFLEX worked on the optimal activation of all available local flexibilities (including aggregators), to deal with congestions, voltage control, etc. LVM project plans to use consumption / production forecasts in order to regulate the network. UGrip addresses the scheduling process, managing uncertainty, but applied to a microgrid instead of a large grid. it computes set points for all sources based on forecastings and real data. Finally, WiseGRID is oriented to DSOs and microgrid operators.

Regarding **task 4**, the UPGRID project included forecast algorithms-based tools to estimate grid status, and in consequence, the network capacity available, grid assets load, etc.

As far as **task 5** goes, UPGRID project addressed the exchange of information between MV and LV levels. They implement real solutions for dispatching at LV level and the interaction with MV dispatching center. Additionally, there are a few projects (DREAM, LVM and INETRFLEX) contributing to reactive energy management.

In link with **task 6**, FLEXNETT and GOFLEX touched Automatic Meter Management system (AMM): the first focusing on storage and the second one oriented to the contribution of final user to the flexibility market.

Many projects now and in the past proposed telecommunication and control architectures (related to AMM, self-healing solutions, DRES integration, grid reconfiguration...) in relation with the topic of **task 7** (DREAM, LVM, SINAPSE, etc.).

Regarding **task 8**, the UPGRID Project developed some relevant tools: an LV advanced supervision mechanism were design and developed applying algorithms-based data analytics on meters data in order to identify the lines and phases which the meters are connected to.

Concerning **task 11**, the UPGRID project integrated operationally AMM and HEMS (Home Energy Management Systems) communications in order to achieve the active participation of grid customers in flexibility and grid management actions. Additionally, BRIDGE initiative carried out specific analysis of the relevance and opportunity of G5 supporting comunication in different grid segments, including the LV one.

The Grid4eu, DREAM, LVM, NEDO, Gotland Smart Grid projects (among others) have automated Secondary Substation and certain telecommunication interfaces have been used in relation with **task 12**.

Several projects (STORes, REDACTIVA, NEDO, LVM, DREAM, UPGRID, etc.) announced good products covering the scope of **task 13.**

Concerning **task 14**, the UPGRID project covered a wide use of Automatic Meter Management (AMM) for grid control and dispatching purposes. A few additional contributions from DREAM, LVM and NEDO have been presented.

Some projects addressed the use of Smart Meters for monitoring LV grids (**task 15**): the LVM project (excluding the consumer), S.G. Gotland project (involving the consumer). The Grid4EU project presented specific systems developed for monitoring LV grid at Sub-Station level. IGREENGrid[29] presented solutions for monitoring and operation of LV grids (SS-OLTC, auto-transformers for LV lines, etc.). STORES introduced the storage as part of the solution, and WiseGRID uses the microgrid concept.

[29] https://www.enedis.fr/igreengrid-0

DREAM and SMARTNET projects addressed Market issues (**task 16**). Results are excellent, but there is still too much work to do to pass from theoretical or simulation results to existing and operational platforms and markets implementation.

Regarding **task 17**, UPGRID project considered grid emergency status information as reference to tigger flexibility actions. Initiatives for solving grid overload situations or grid planning by means of flexibility schemes are already on the stage, as analysed in some project included in the Business Model working group of the BRIDGE initiative[30].

Main gaps to cover this functional objective

Regarding **task 1**, network switches were not covered in protection schemes neither in remote control. Moreover, Two-way powerflows control and protection are mainly focused on the DG inverters and meters. Other Low Voltage grid components could be considered specially in the scope of the secondary substation.

Regarding **task 2,** the cost-effectiveness and "automation" concept must be studied more in deep. The data protection and cyber security approaches for distributed elements shall be further explored as well as the use of decentralized Storage for grid purposes.

Establish measurable results in the on-going projects to have a reference to evaluate the improvements obtained by future works (**Task 3**). Use of forecasting and real network data for the optimization of the scheduling of the "grid configuration" aspect.

Regarding **task 4**, further development is needed so as to address the "grid monitoring" aspect.

A wide part of the LV system topology seems to remain not covered for **task 8.**

Regarding **task 9**, some progresses can be noted regarding the implementation of IEC 61850 but aggregation of information models and the application of IEC61850 as a reference shall be further developed.

Systems oriented to guarantize a proper use of data should be developed within **task 10**, in order to make possible the use of private data automatically anonimized to produce improvements in grid operation and maintenance.

Regarding **task 14** there are no references observed about grid automation processes being addressed by the core application of AMM and large demonstrations implementing a wide set of uses are still necessary.

Larger demonstrations are necessary to entirely cover **task 15**.

Regarding **task 16** additional work is needed to pass from theoretical or simulation results to existing and operational platforms and markets implementation.

No clear references are observed about the coordination applied between "technical grid control" and "market mechnisms on power balancing" (**task 17**).

Proposal of evolution for the tasks

Task 1 could be reformulated to consider other protection aspects. Another proposal is to separate the concepts of "Protection Schemes" and "Remote Control Systems" including the concept of "Automation".

Task 2 could be:

- refocused on the cost-effectiveness of the solutions proposed. Decentralized storage could be separated in a different item and clarifies;
- merged with methodologies in **task 10** for the data protection and cyber-security aspects;

[30] https://www.h2020-bridge.eu/

- complemented with details of the expected domains the "automatic control" concept is expected/interesting to be applied to the LV grid (protection, reconfiguration, self-healing, optimization, coordination, etc.);
- merged with **task 1** regardind the “automatic control” concept.

Task 3 could be:

- reformulated and clarified to express the meaning and scope of "grid configuration" in LV networks.
- merged with **task 4** ("LV and MV monitoring combined...") taking into account that both could target similar features in the field of grid capacity availability, congestion, perfomance, etc.

Task 4 could be reformulated to highlight the relevance of the forecast algorithms design, development and application.

Task 5 could be clarified so as to reach the objective of the task. A focusing on the production of written deliverables describing the information to be exchanged could be considered.

Task 6 could be:

- included within D1 since part of it is related to load control for flexibility.
- modified by removing the part of the task using the AMM communication structure as an informarion channel (consumption and generation information and events gathered from meters are already used for Active Demand Management purposes). The task could be addressed towards the use of the AMM communication infrastrucutre, and the meters as the components that could interact to the load controllers (Home Energy Management Systems), for load control or, better, for Active Demand Management.

Task 7 could be:

- merged with tasks addressing similar topics: "New control architectures" can be merged with "information models & 61850" (**task 9**) and "communication infrastructure supporting integration" (**task 11**). "Optimized operation" can also be merged with "new algorithms to identify system topology" (**task 8**);
- specified in a more detailed way to define the content and scope of the task: the following topics shall be considered relevant for those possible addressed topics:
  - coordinated Grid & DER (generation/consumption/storage) control use cases, and related architectures, for the optimization of flexibility from different (harmonized) perspectives (e.g. grid performance, efficient energy balance and saving, economic profitability, ...);
  - application of advanced ICT-based approaches (IoT, cloud computing, cyber-security, blockchain, ...) for both grid data storage and computing on new (HW & SW) architectural schemes;
  - to go one step ahead from LV remote monitoring and control architectures to "AUTOMATION architectures";
  - forecasting, estimation, control planning, control execution and automation assintance to operators;
  - microgrid-based management approaches to be applied to the LV distribution grid (web-of-cells concept based structuring and coordination schemes).

Task 8 could be:

- merged with **task 7** in a new task called: "Optimized control of MV and LV based on Artificial Intelligence systems, big data, and higher LV control (including identification of LV grid topology, and others);
- reformulated: by providing more detail in the definition and scope of "System Topology" whose topology is intended to be (automatically) identified. Both topology of specific grid sections (e.g. output feedres, lines and/or phases of a secondary substation, etc.)

and/or of specific grid components (switches/breakers position, etc.). Other dimension to be considered is the time needed to identify that system topology and applications of that identification (maintenance, failure location, grid reconfiguration, grid planning, etc.) for which medium or short term or real time topology identification could be required.

Task 9 could be:

- merged with "control architectures" and with "Communication infrastructure supporting integration" (**task 11**) and called: "Telecommunication and control architectures for integration od DER, EV, consumers, prosumers and other new users";
- reformulated to provide a more detailed description about both factors involved, what kind of information the models are expected/desired to be integrated/aggregated and the degree this integration should conform IEC 61850. This information model could also be compliant to CIM (Smart Grids Common Information Model) set of standards, namely IEC 61970, IEC 61968 and IEC 62325.

Task 10 could be merged with the Functional Objective D11 (Cyber security - System Approach) with a specific domain of the LV grid monitoring and control. In the case of keeping this task in this D8 FO, the content and scope of the task should be defined more in-depth in the domain of the smart LV grid monitoring and control. In this domain, the active participation of the prosumers (flexibility, grid performance and instability, etc.) is starting to be very relevant so adapted data gathering, persistency, protection and privacy schemes will be of key importance. Other relevant domain could be the definition of cybersecurity means related to the LV distribution control room in coordination specially to the tele-operable devices being deployed in that LV grid segment, including the connections to the DERs. Completing the data protection and cybersecurity schemes, the definition of related risk impact assessment could be also included.

Task 11 could be merged with **tasks 7** and **9** (cf above) or reformulated: three main domains could be considered as relevant in the LV grid monitoring and control:

- integration of the LV grid management with other grid segments (MV specially) and related control romos;
- integration to the customer premises/systems to allow the active participation in the energy market and in the grid operation optimization;
- integration to systems of other energy scenario actors (retailers, aggregators, TSOs basically) that require mainly access to grid status and data, in order to optimize and automate processes they cooperate;
- other possible dimension to consider in the reformulation is which protocols are applied for that integration. For instance, the detail of the application of 5G or Broadband PLC could be relevant.

Task 12 could be:

- added to the new topic "Telecommunication and control architectures…" (cf above **task 9**) that could include also interfaces for Secondary Substation (SS), consumers, DERs, etc;
- reformulated to be structured by 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.).

Task 13 could be reformulated to focus on the optimization and industrialization (design, cost, performance, manufacturing processes, etc.) of the measuring devices that are supposed to be at some kind of prototyping stage. It could be considered the development of devices to measure other interesting LV parameters related to the quality and performance of the grid infrastructure like harmonic, noise, latency or line impedance distribution[31].

Task 14 could be:

- complemented to add the idea of large demonstration and of using AMM as a component of a wider multi-use automation system.
- harmonized with the tasks included in the Functional Objective D10 (Smart metering data processing and other Big Data applications). The issue of automation via AMM could be a subtask of a global task of LV grid management Automation.

Task 15 could be complemented by "Solutions that prove to be applicable at a large scale with a low cost" which is an important aspect to be added. A possible new definition for this task in the domain of LV grids monitoring and operation could be focused on “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 modeling, scheduling and execution schemes, the improvement of the support to grid operators, preventive/predictive maintenance programing or grid assets planning”.

Task 16 could be:

- reformulated to focus on theoretical and simulation studies as well as real implementation of the most promising solutions;
- modified to create a new task focusing on the potential role of customers in the electricity market[32] providing different kind of services in the domain of flexibility, ancillary services or grid monitoring, operation and performance by means, basically, of their (manageable) energy generation, consumption and storing capabilities.

Task 17 could be:

- merged with the last two tasks (**tasks 16** and **17**) the following way: “Market rules and mechanisms for provision of ancillary services (recommendations, coordination with technical aspects, implementation, operation, demonstration, ...)”;
- modified to provide a more specific task definition considering specific grid cases, involving also AMM and AMI, in which the technical grid control and the market-based power balancing would be relevant (aggregation, VPP, microgrids, prosumer communities, secondary substation overload management, grid section instability, grid section planning, etc.)[33].

[31] This quality analysis could be relevant, for instance, for preventing problems in PLC infrastructures

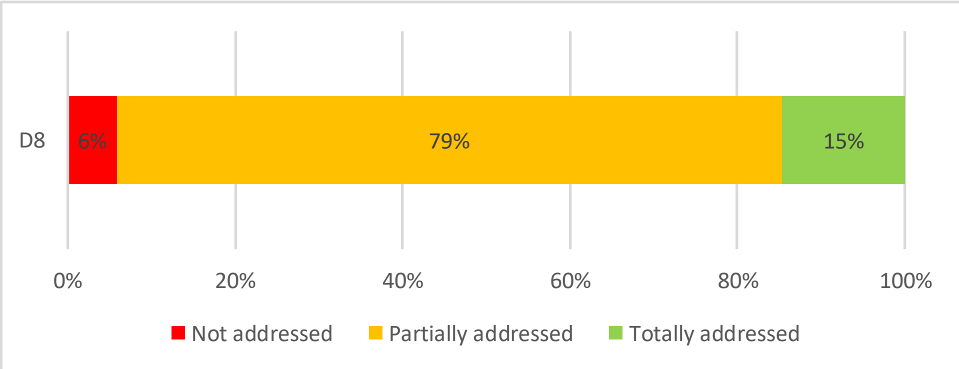
[32] The recent EU Winter Package Electricity Market Directive includes relevant statements for an active participation of the consumers in the electricity market

[33] A good reference for that task definition would be the considerations of the Winter Package about power balancing (aggregation and flexibility basically) and electricity market participation that would require specific grid control actions.

General conclusion for the coverage of the functional objective

- Most of the tasks are partially covered (**tasks 1, 2, 3, 5, 6, 8, 10, 11, 12, 17**);
- Specific aspects shall be developped within each task to address them totally;
- In terms of evolution for the tasks, in general the tasks shall be clarified, merged (**task 7, 8, 9, 11 or tasks 16 and 17**) or complemented since some of them are identified as too general.

⇨ **Final coverage of the Functional objective:**



D9 - Automation and control of MV network

1. Integrated voltage control and congestion management in distribution networks by means of smart transformers
2. Middleware layers (with multi-agent systems) as a possible alternative for the management of MV networks hosting large share of renewables (including storage)
3. New actuators (e.g. switches) and new sensors (e.g. fault detectors, voltage and current sensors) for MV network
4. 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
5. Large scale deployment of smart substations under the IEC standards (61850 and 61970/61968 CIM)
6. New tools (with advanced algorithms) taking advantage of the increased monitoring so as to optimise topology (as a flexibility option in the operations)
7. Operational scheduling tools for optimal grid configuration based on day-ahead forecasting and real network data to maximize (DER penetration) or minimize (network congestion
8. Interactions between TSOs and DSOs: increase observability of the distribution system for transmission network management and controllability with better forecasting and data flow
9. Optimal management and activation of local flexibilities thanks to the information exchange and the new market/regulatory frameworks (active and reactive power management techniques for generators and loads)
10. New equipment and associated software for faster fault detection and isolation times.
11. Validation of self-healing network solutions using smart controllers in smart secondary substations
12. New tools for MV power system stability analysis with a high penetration of power electronics
13. Automatic fault clearing procedures with automatic power restoration
14. Active management and control using communication infrastructures at MV level restricted in bandwidth
15. Communication interfaces at smart substation level with the associated data protection and cyber security methodologies
16. Design and optimise (costs) dedicated ICT infrastructures for MV network management
17. Finding the right level of grid automation and the relevant parameters depending on the characteristics of the different grid architectures in Europe
18. Recommendations on market rules and mechanisms for provision of ancillary services (e.g. reactive power provision) provided through the MV network

List of projects considered

Seventeen projects have participated in the survey and claimed to contribute to Functional Objective D9.

FP7/H2020 projects		Other projects	
eBADGE	SMARTNET	Dynamo	REDACTIVA
inteGRIDy	SUNSEED	FASAD	Smart Grid Gotland
INTERFLEX	TILOS	HEILA	WIVE
NETFFICIENT	UPGRID	NEDO	
RESERVE	WiseGRID		

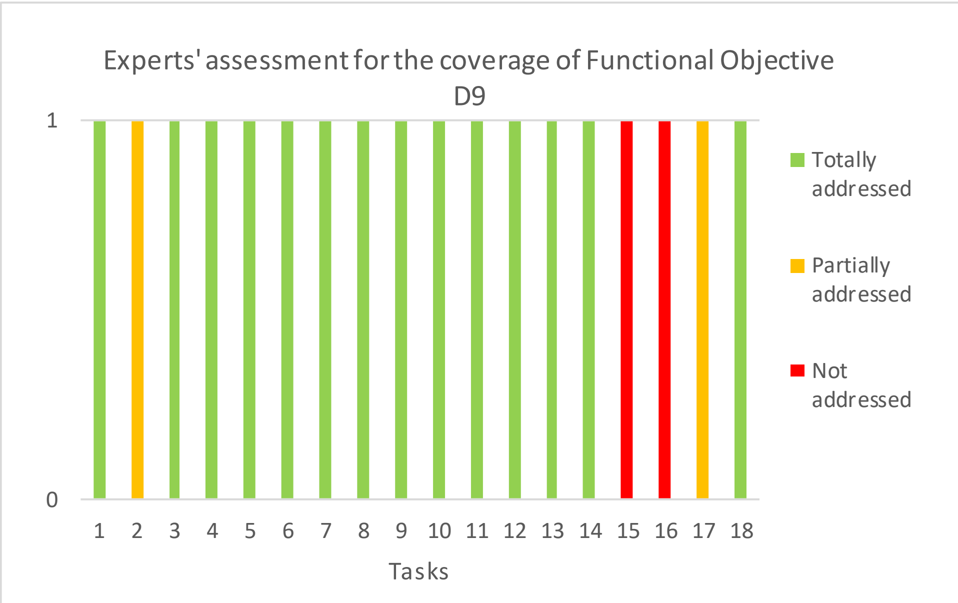
List of experts consulted

The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective D9.

Organisation	Name
HEDNO	Markos Champakis

Overview of the coverage of the Functional Objective according to experts' views

The expert consulted considered most of the tasks of this FO as totally addressed (**tasks 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 and 18**). Two tasks are considered as partially addressed (tasks 2 and 17) and two as not addressed (**tasks 15 and 16**).



Overall achievements reached under this Functional Objective

Three projects tackled the aspects of **task 1**: the NEDO project, the WIVE project with their Feeder line protection involving smart transformers with real-time communication capabilities and the UPGRID project with their modular solutions to monitor, automate and control LV/MV networks.

Regarding **task 2** The Dynamo, eBADGE and SUNSEED projects have partially covered the task as the Dynamo project has developed DSO capabilities.

Six projects tackled the aspects of **task 3**: the FASAD project is using fault detectors, voltage and current sensors for MV network, the REDACTIVA project has developed early detection of faults systems for predictive / preventive maintenance of the distribution network, the Smart Grid Gotland project, UPGRID and TILOS project. The WIVE project has implemented a new relay type with wireless communication capabilities

At least the WIVE project experiments line differential and intertrip protection schemes over 4G/5G connections in link with **task 4.**

At least the UPGRID project has experimented at a large scale the low voltage Network Management System (LVNMS) which are connected to secondary substation (**task 5**).

Five projects tackled the specificities of the **task 5**: among them, the Dynamo project has developed DSO capabilities tools, the inteGRIDy project has implemented an MV Distribution Networks Management Tools. The SMARTNET project has developed an ICT system allowing real time monitor and control (voltage and secondary frequency regulation) of hydro power stations connected to MV and HV network sections in Ahrntal (Südtyrol).

The WiseGRID project addressed the **task 7**. WiseGRID cockpit will support DSOs by means of monitoring, decision support, control and optimized operation enabling grid-friendly integration of heterogeneous and distributed energy resources.

The NEDO, SMARTNET and SUNSEED projects addressed **tasks 8**. More precisely, the SMARTNET project tested facility for DSO system monitoring control.

Two projects fully addressed **task 9**, the Dynamo project with their flexibility market model providing flexibility to DSO's and BRP's at a standardized way; the SMARTNET project with, among other, their TSO-DSO ancillary services market simulator.

The FASAD project has developed a prototype software tool to calculate the improved reliability of supply for faster fault detection and isolation times (**task 10**). The REDACTIVA project has developed applications to avoid undesired "isle" generation. The WIVE project uses wireless technologies enabling significant cost savings and increasing flexibility. The fault detection and isolation capabilities can be extended to remote segments of the grid. The SUNSEED, UPGRID and Smart Grid Gotland are also addressing the task.

Task 11 is fully addressed by the Smart Grid Gotland and NEDO projects.

The RESERVE project fully addressed **task 12** with its Linear Swing Dynamic (LSD) concept able to exploit the smartness of the power electronic interfaces of modern renewable energy sources to make up for the loss of mechanical inertia given by rotating mass in the current grid.

The NEDO project fully addressed **task 13**. Moreover, the FASAD project has tested self-healing solutions and the WIVE project has developed fault clearing mechanism in-built to the line differential and intertrip protection schemes.

The NEDO and WIVE projects addressed **task 14**. As example, within the WIVE project, 4G and 5G communication networks were experimented for active management and control.

Task 18 iwas at least fully addressed by the SMARTNET project and its TSO-DSO ancillary services market simulator.

Main gaps to cover this functional objective

Tasks 2, 15, 16, 17: further research is needed to cover all the aspects of the tasks.

Proposal of evolution for the tasks

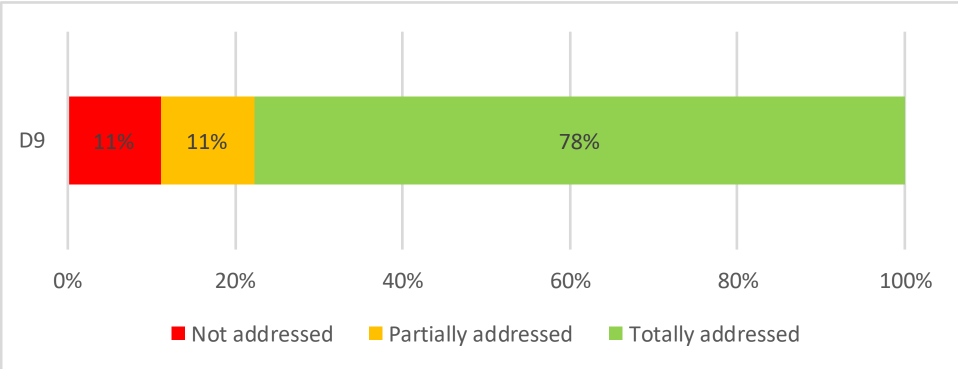
Tasks 2, 15, 16, 17: keep the task as it is so as to complement the coverage of the tasks.

Tasks 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 and 18: shall be removed.

General conclusion for the coverage of the functional objective

- Fourteen out of eighteen tasks are assessed as totally addressed for the Functional objective;
- In terms of evolution for the tasks: only two tasks have been not addressed (**tasks 15 and 16**) or partially addressed (**tasks 2 and 17**) and will need further research to cover all the aspects of the tasks.

⇨ **Final coverage of the Functional objective:**



D10 - Smart metering data processing and other big data applications

1. Develop highly-distributed, low-cost sensors for the optimal management of the network (power flow optimisation, fault detection, power quality, hosting capacity for DG or EV, demand response, etc.)
2. Development of mathematical approaches to describe consumption behavior from data mining techniques (load forecast, aggregation of consumer profiles) while ensuring the availability of the data for market players and customers
3. Development of mathematical approaches to forecast generation from PV and wind power with data mining techniques, while ensuring availability of the data for market players and customers
4. Development of mathematical approaches to predict ageing and lifespans of network component (e.g. transformers, switches, breakers, etc.) including the associated ICT infrastructure (sensors, communication infrastructures) and smart meters
5. Novel data mining and data processing techniques to improve the reliability of the power system
6. Improve the efficiency of large data mining processes
7. Develop data protection tools (access, authentication, and encryption), data publishing systems and data storing systems (e.g. web dashboards for data management, etc.).
8. Ensure the standardisation of data models (e.g. CIM)
9. New IT solutions to process large data streams (cooperation with the bank industry).
10. Develop distributed online analytical data stream processing
11. Efficient systems to obtain information from different and disparate sources of data (standardization and interoperability, data privacy and cyber-security issues, etc.)
12. Develop and test solutions based on smart metering information and other sources of big data in order to improve the operation of the grid or to reduce costs while maintaining the quality of service
13. Recommendations for data privacy and data use by the different stakeholders of the electric system, including customer acceptance
14. Recommendations for new regulations to provide personalized services and tariffs to individual customers
15. Business models for providing new energy services thanks to the availability of large-scale data bases and advanced data-mining techniques

List of projects considered

Eighteen projects have participated in the survey and claimed to contribute to Functional Objective D9.

FP7/H2020 projects		**Other projects**
ANYPLACE	RealValue	Dynamo
FLEXCOOP	SMARTEREMC2	FLEXNETT
FLEXICIENCY	SUNSEED	LVM
GOFLEX	TILOS	NOISEEK
INTERFLEX	UPGRID	SINAPSE
NETFFICIENT	WiseGRID	SMARTPV

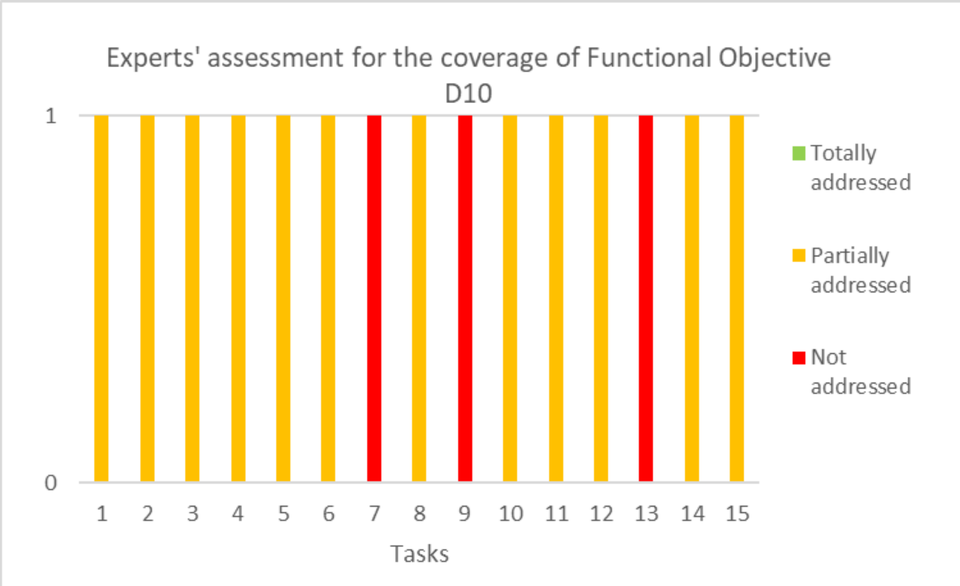
List of experts consulted

The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective D9.

Organisation	Name
INNOGY	Carmen Calpe

Overview of the coverage of the Functional Objective according to experts' views

The expert consulted considered that twelve out of fifteen tasks were partially addressed (**tasks 1, 2, 3, 4, 5, 6, 8, 10, 11, 12, 14 and 15).** Three tasks are considered as not addressed (**tasks 7, 9 and 13**).



Overall achievements reached under this Functional Objective

Regarding **task 5**, some good first solutions have been implemented (in the LVM, SINAPSE or UPGRID projects) such as Real-time external events correlation for the SINAPSE project.

The LVM project addressed **task 6.** At least three projects (SINAPSE, GOFLEX and FLEXCOOP) addressed **task 10**. As an example, the GOFLEX Energy flexibility management system included capability for online training and forecasting models using distributed computed capability.

Concerning **task 12**, the INTERFLEX project contributed to smart metering data utilization by developing new business models for providing new energy services (the Smart Grid Hub). SMARTEREMC2 result "Demand Response Management System (DRMS)" made use of its Smart Grid data analytics platform (SDAP) in order to intelligently establish DR campaigns.

Main gaps to cover this functional objective

For most of the tasks partially addressed, further development is needed so as to cover entirely the activities. Some examples can be highlighted. An easy monitoring of the LV is key enabler to facilitate small flexibilities considered in **Task 1**.

Task 2 could be improved by using further developments in sensors and the combination with other data sources to get a broader understanding.

Regarding **Task 3**, further developments could be done to include in the forecasting flexibility options of prosumers, storages etc.

Concerning **Task 7**, further develpments could be necessary to make the data mining processes in large scale available for the operational processes.

Proposal of evolution for the tasks

Tasks 1, 3, 4, 10 could be clarified.

Tasks 2, 5, 6, 7, 8, 11, 12, 14 and 15 could be merged so as to combine common topics.

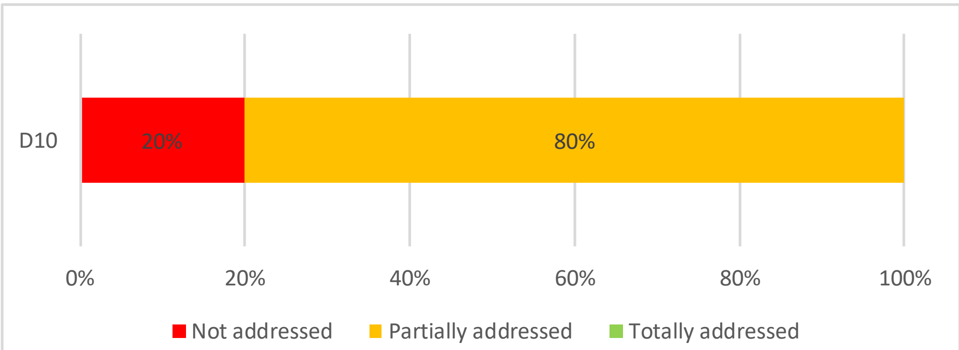
Task 9 could be extended to consider not only the bank industry.

Task 13 shall be kept as it is.

General conclusion for the coverage of the functional objective

- Twelve out of fifteen tasks are assessed as partially addressed and shall be further developed to cover all their scope.
- Three tasks have been not addressed.
- In terms of evolution for the tasks: in general the task shall be clarified and simplified.

⇨ **Final coverage of the Functional objective:**



D11 - Cyber security (system approach)

List of tasks included in this functional objective

1. Develop and demonstrate physical and cyber security protections to avoid fraudulent access through physical installations (primary and secondary substations, MV and LV lines, etc.) to ICT systems
2. Develop recommendations to make the IT/OT structure of power systems resilient and less vulnerable by design (focusing on the functionalities)
3. Engage a common work with TSOs since cybersecurity issues are common to both transmission and distribution system operators at inter-connected infrastructures
4. Study the risks and vulnerabilities related to the use of public ICT infrastructure for smart grid purposes, e.g. connection with the customers through smart meters and energy boxes (for example for demand-response signal or metering)
5. Study the risk and vulnerabilities related to the use of wireless communications at the customers' premises but also in critical infrastructures like substations
6. Study the risk and vulnerabilities related to SCADA systems as a means to provide remote supervisory and control (e.g. high connectivity of SCADA ICT networks with other ICT networks such as the corporate intranet or even the Internet)
7. Authenticating and authorizing users (maintenance personnel for instance) to IEDs (Intelligent Electronic Devices) in substations or smart meters in such a way that access is specific to a user
8. Define models for encrypted and authenticated orders which could be common to all smart grid stakeholders
9. Develop and demonstrate an integrated solution covering cyber-security issues of all infrastructures involved so as to avoid specific solutions for each installed equipment

List of projects considered

The following projects have participated in the survey and claimed to contribute to Functional Objective D11.

FP7/H2020 projects	Other projects
ANYPLACE INTERFLEX SMILE SUNSEED	FLEXNETT LVM SECUREGRID

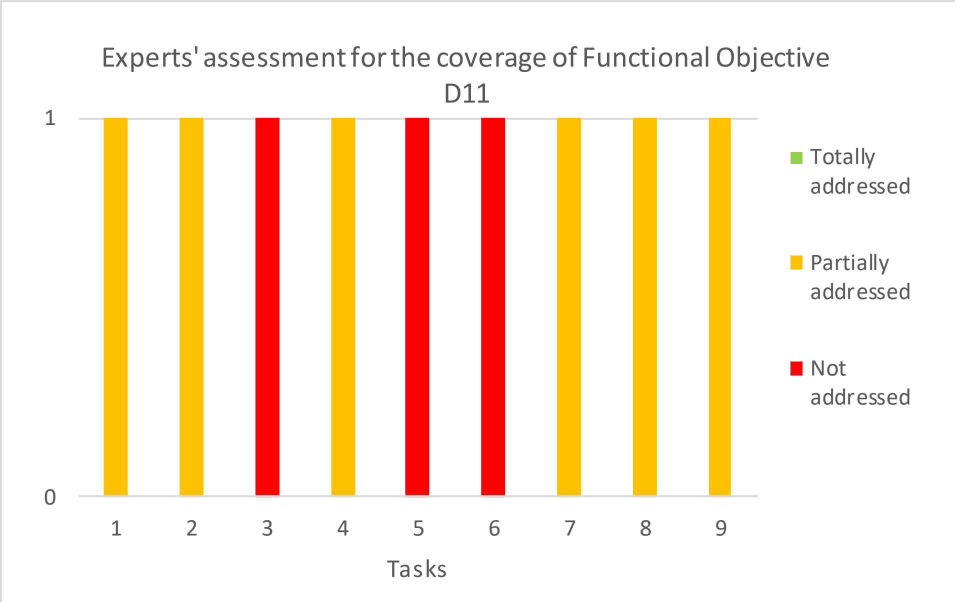
List of experts consulted

The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective D11.

Organisation	Name
EDPD	Tiago Filipe Simão

Overview of the coverage of the Functional Objective according to experts' views

Only one expert sent his assessment on the tasks, and he considered that no task was totally addressed. One third of the tasks are not addressed (**tasks 3, 5 and 6**) and others are partially addressed.



Overall achievements reached under this Functional Objective

SECUREGRID projects partially addressed the **task 2** as its model establishes the degree of security that an IED can achieve for each of the security requirements (Confidentiality, Integrity, Availability and Non-repudiation).

Considering **task 4**, most of the projects such as LVM, SMILE or FLEXNETT, studied partially risks and mitigated it.

Regarding **task 7**, LVM project developed several levels of authentification before log-in and SECUREGRID provided a new version of IEDs with greater security measures that reduce the risk of an attack through communication networks.

ANYPLACE, SMILE or SUNSEED addressed the **task 8** on a partially/fully level.

Main gaps to cover this functional objective

Regarding **task 1**, additional information about LVM and SUNSEED projects are required to assess the level of cyber security protection on physical installations.

Expert did not mention any gap for the **task 2**. Overall progress on resilience and vulnerability of the IT structure is still needed.

Considering **task 3**, DSO and TSO relationship must be studied and clarified.

Regarding **task 4**, in LVM, use of customer´s meters are limited to technical data regarding the delivery quality no communication (HAN interface) with the customer via the meter is planned.

Task 5, projects concerned, such as SMILE, have to develop wireless applications to really address the task.

SCADE topic covered by **task 6** requires further development from listed projects.

Proposal of evolution for the tasks

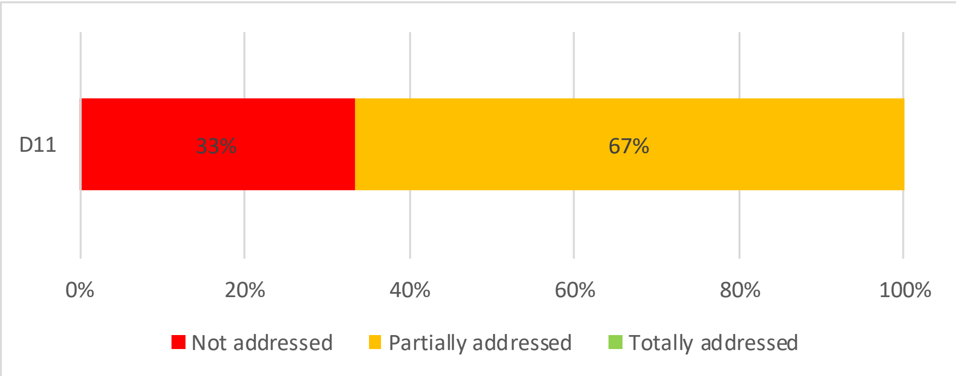
Tasks 1 and 9 need to be a priority work in listed projects.

Tasks 2, 3, 4, 5, 6, 7, 8 could be further studied.

General conclusion for the coverage of the functional objective

- Overall, no task has been totally covered regarding the cyber security functional objective.
- One-third of the tasks (**tasks 3, 5, 6**) needs important progress as no project covered their topic.
- Other tasks have only been addressed partially by the different projects, and they need further developments from the project.
- In terms of evolution for the tasks: expert did not specify any specific evolution for the tasks

⇨ **Final coverage of the Functional objective:**



CLUSTER 4 - PLANNING AND ASSET MANAGEMENT

D12 - New planning approaches and tools

List of tasks included in this functional objective

1. The planning issues of the future power system must be considered by studying its integration in the whole energy system, i.e. by assessing the added value brought by the coupling between electricity, gas as well as heating and cooling networks (cf. D7)
2. Study all alternatives (degrees of freedom) to network reinforcements and new lines/links e.g. by using energy storage, power electronics, etc.
3. Develop advanced mathematical (probabilistic) and computational tools so as to scan the whole phase space (use of High-Performance Computing facilities)
4. Methodologies and simulation packages allowing DSOs to determine where the connection of new generation units, loads and storage should be encouraged (signal to market players)
5. Increased the level of robustness of the future network to face extreme events due to climate change (high temperatures, floods, etc.) and due to natural hazards (earthquakes, etc.)
6. Methodologies to improve the environmental footprint and the social acceptance of new equipment
7. 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.
8. Optimise the permitting procedures by integrating all constraints imposed by spatial planners in the simulation tools

List of projects considered

The following projects have participated in the survey and claimed to contribute to Functional Objective D12.

FP7/H2020 projects		Other projects
INTERFLEX INTERPLAN PlanGridEV	UPGRID WiseGRID	AMPACITY CLOUDGRID SMARTER NETWORK STORAGE

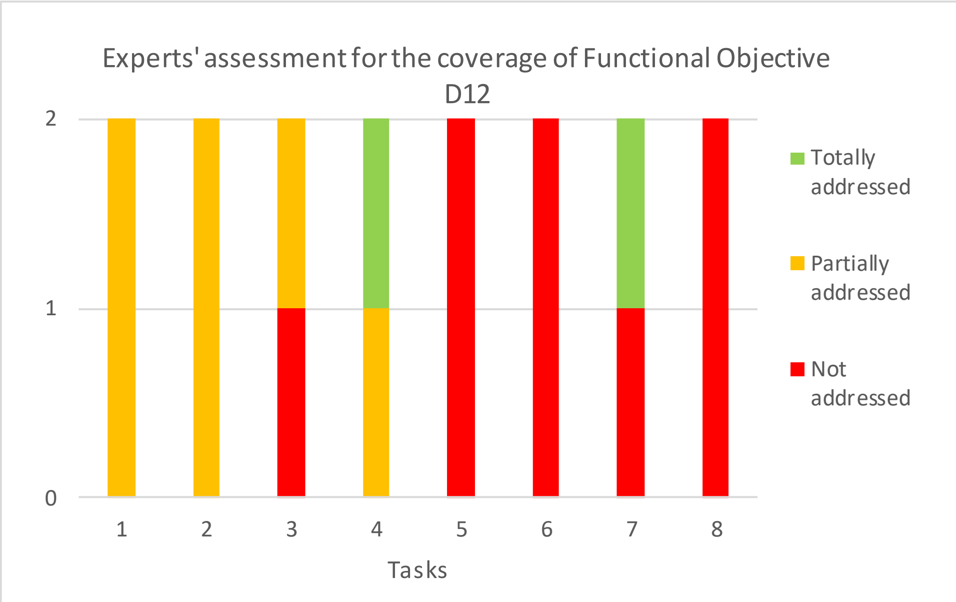
List of experts consulted

The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective D12.

Organisation	Name
EDPD	Tiago Filipe Simão
TRACTEBEL	Niels Leemput

Overview of the coverage of the Functional Objective according to experts' views

Half of the tasks have been considered as unanimously not addressed (**tasks 5, 6, 8**) and partially or not addressed (**task 3**). Three other tasks are assessed as partially addressed by all the experts (**tasks 1 and 2**) and totally or partially addressed (**task 4**). **Task 7** has been subjected to different assessments as one expert estimated the task as totally covered and another expert as not addressed.



Overall achievements reached under this Functional Objective

Regarding **task 1**, INTERFLEX and INTERPLAN projects planned to develop a network planning tool, but more focused on the final consumer.

Considering **task 2**, project like PlanGridEV is dedicated to a specific technology, such as EV and storage, but did not address all possible alternatives.

Except Smart Network Storage which developed a mathematical model to analyse the contribution of storage to security of supply, no project addresses a developing advanced mathematical tool to scan the whole phase space and cover the **task 3**.

Regarding **task 4**, PlanGridEV project provided a demonstration for a simulation tool linked to the ability of DSOs to anticipate future connections on the grid.

Considering **task 7**, the UPGRID project developed a set of services relying on advanced algorithms to monitor the LV grid based on information provided by smart meters, existing systems and remote terminal units. Next step would be to focus on planning process and the flexibility of grid extensions to perfectly cover the topic.

Main gaps to cover this functional objective

Project developers must consider the entire energy system to cover the **task 1**, and not only the end-consumer.

To progress in the coverage of **task 2**, results from PlanGridEV and SMARTER NETWORK STORAGE could be used to complement the CLOUDGRID Key Exploitable Result 2. The method could support another solution to decrease the cost for grid operation but also avoid or delay grid investment by studying all alternatives.

Regarding **task 3**, projects still need to consider the whole phase space, and not only specific functions.

Task 4 has been well covered by few projects, like PlanGridEV and WiseGRID.

Next step for **task 7** and projects involved would be to focus on planning process and the flexibility of grid extensions to perfectly cover the topic. Expand the different simulation tools developed in the projects with the possibility of integrate the data coming from the field (smart meters, etc) to improve the planning process and the associated tools.

Task 8 should integrate cartographic data in the simulation tools that allows the planner to optimize the permitting procedures by integrating all constraints imposed.

Proposal of evolution for the tasks

Task 1 could be reformulated to integrate a tool to develop all the energy value chain, and to assess cross-sector coupling of energy systems.

Task 2 could be reformulated to assess alternatives to network reinforcements and new lines/links e.g. by using energy storage, power electronics, etc.

Task 3 could be reformulated to specify the development of an advanced mathematical (probabilistic) and computational tools to improve planning and asset management.

Task 4 could be reformulate as "Methodologies and simulation packages allowing DSOs to assess the connection of new generation units, loads and storage".

Tasks 5 and 6 could be merged according to the experts, also specify to develop methodologies and studies.

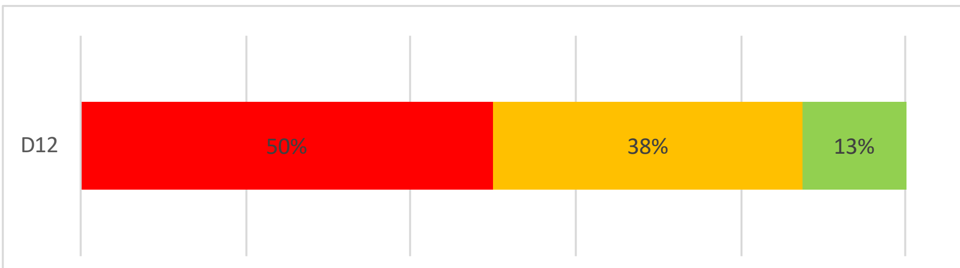
Task 7 required no specific evolution are considered for this topic.

Task 8 could be merged with standardization tasks.

General conclusion for the coverage of the functional objective

- Some projects developed solutions linked to the tasks but they did not answer perfectly to the topic (**tasks 1, 2, 3 and 7**).
- Three tasks have not been covered at all by the listed projects (**tasks 5, 7 and 8**) and remain interesting topics for experts.
- Only one task has been partially or totally addressed, thanks to PlanGridEV Project, and made good progress.
- In terms of evolution for the tasks: **Tasks 5 and 6** could merge while other could be rephrase to be more specific according to the experts.

⇨ **Final coverage of the Functional objective:**



D13 - Asset management

1. Insert results from research related to ageing models and condition/risk-based maintenance into planning tools so as to account for maintenance constraints (and flexibilities) when performing planning studies
2. Design, implement, and test in the field maintenance approaches based on new robotic systems in order to reduce the time for maintenance and mitigate the risks associated to service interruption, while increasing safety for field maintenance teams.
3. Innovative modifications in elements or components of the electricity system to facilitate maintenance approaches based on new robotic systems
4. Develop and use tools providing SoH (State of Health) estimates and probabilities of failure as a flexibility option when operating the network close to its physical limits so as to optimize the time of maintenance and the impacts on operations
5. Develop software and hardware to improve remote maintenance operations (especially for the new digital environment)
6. Develop accurate ageing (and failure) models accounting for the new cycling profiles (including extreme events) both for the power component (lines, substations, etc.) and the ICT infrastructure, by using, among other, data mining techniques and probabilistic approaches
7. Develop accurate SoH estimation techniques as an input to predictive maintenance (e.g. components' wear, oil level in transformer oil pits, SF6 level in switchgear) to better estimate the probable distance (time) to failures (link with ageing and failure models)
8. Specify and perform laboratory tests to qualify the modelling work on SoH, ageing laws, failure laws
9. Tools for new maintenance strategies, i.e. conditional maintenance (predictive maintenance) and risk-based maintenance based upon ageing models and optimization algorithms able to address different time scale (from operations to planning)
10. Training of maintenance operators for their adaptation to the new digital environment (e. man-machine interfaces) and new robotic solutions
11. 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

List of projects considered

Five projects have participated in the survey and claimed to contribute to Functional Objective D13.

FP7/H2020 projects	Other projects
INTERFLEX UPGRID WiseGRID	AMPACITY OSIRIS

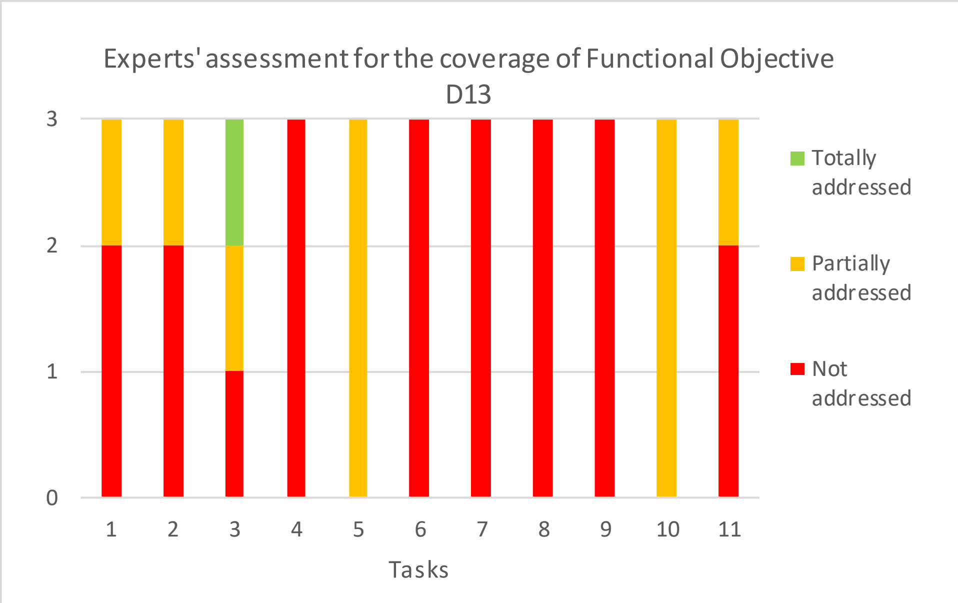
List of experts consulted

The following experts have been consulted. They have provided their expert views regarding to which extent the results from the projects considered contribute to cover the tasks listed within Functional Objective D13.

Organisation	Name
CEZ Distribuce	Vaclav Janoušek
SINTEF	Andrei Z. Morch
VTT	Seppo Hänninen

Overview of the coverage of the Functional Objective according to experts' views

The expert consulted considered that 2 tasks were partially addressed (**tasks 5 and 10**). Five tasks are considered as unanimously not addressed (**tasks 4, 6, 7, 8 and 9**). Three tasks are considered both not addressed and partially addressed (**tasks 1, 2 and 11**) and one task indicates divergences between the experts (**task 3**).



Overall achievements reached under this Functional Objective

Regarding **task 3**, the OSIRIS project is investigating LV PLC diagnosis.

Regarding **tasks 5 and 10**, The UPGRID project has developed The Low Voltage Network Management System (LV NMS) providing field crews with a real time view of LV network diagram to manage and solve LV network incidents, and a way to confirm supply restoration.

Considering **task 11**, WiseGRID cockpit will support DSOs by means of monitoring, decision support, control and optimized operation enabling grid-friendly integration of heterogeneous and distributed energy resources.

Main gaps to cover this functional objective

Most of the aspects of the tasks shall be further developed.

Proposal of evolution for the tasks

Tasks 1, 6 and 9 could be modified to create a new task: "Develop accurate ageing (and failure) models and condition based maintenance tools accounting for the new cycling profiles (including extreme events) both for the power component (lines, substations, etc.) and the ICT infrastructure, by using, among other, data mining techniques and probabilistic approaches."

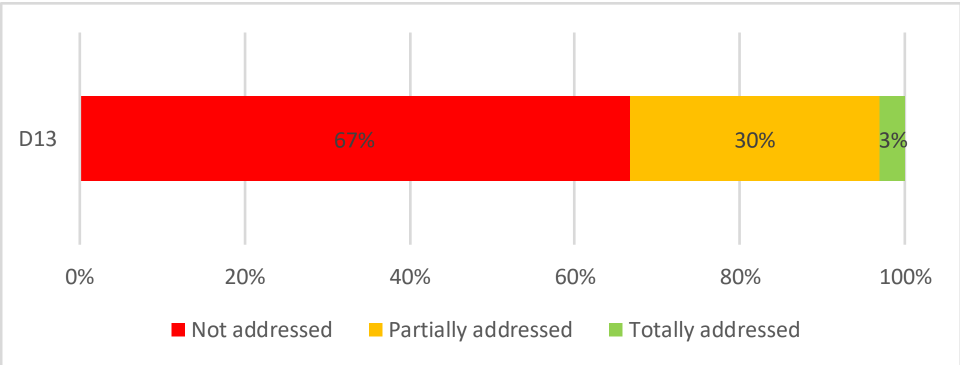
Tasks 2 and 3 could be merged and modified to create a new task: "Design, implement, and test in the field maintenance approaches based on new robotic systems". This task could highlight in “data preselection” needed for maintenance right in the metering devices in order to reduce data coming to SCADA.

Tasks 6 and 7 could be merged.

General conclusion for the coverage of the functional objective

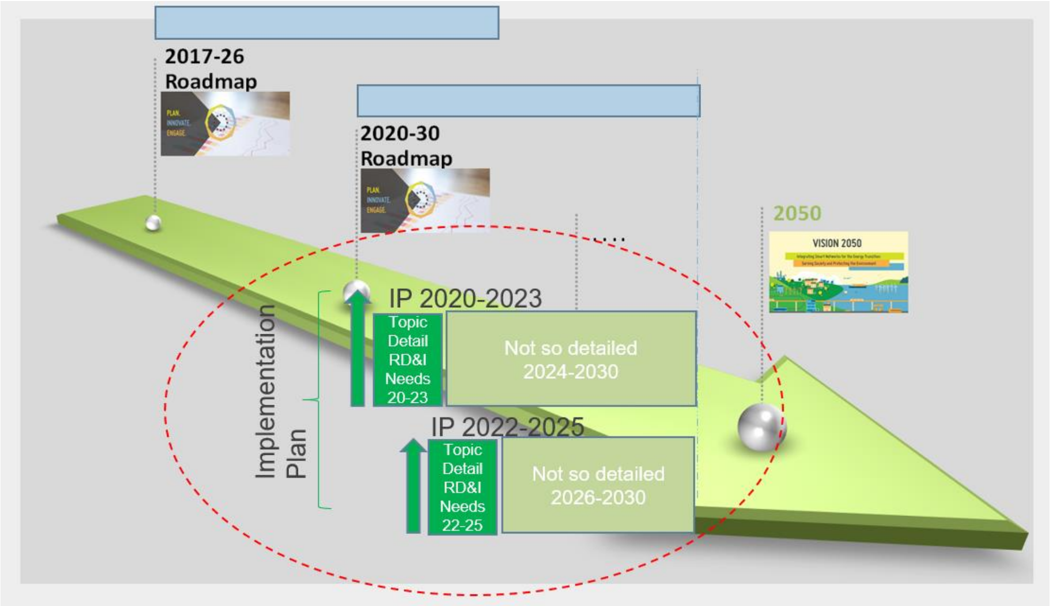
- Some activities on-going but additional work needed to cover entirely the tasks.
- Most of the tasks (nine out of eleven) with activities have not been addressed at all.
- In terms of evolution for the tasks: In general the tasks shall be merged based on common topics (i.e. **tasks 1, 6, 9**, **tasks 2 and 3**; **tasks 6 and 7**.)

⇨ **Final coverage of the Functional objective:**



PART 4 – TOWARDS THE NEXT ROADMAP

In 2019, the update of the ETIP SNET roadmap (for the years until 2030) and the Implementation Plan (for the years 2020-2023) shall be carried out as illustrated by the figure below:



The general guidelines for this process will be the following:

- The updated roadmap shall be simplified (less detailed) and in line with the Vision 2050[34];
- The updated roadmap (and the associated implementation document, i.e. the implementation plan -IP- shall be the outputs of a broad consultation of the ETIP SNET members (and beyond) as for the Vision 2050;
- The updated roadmap (and the associated IP), shall be drafted by the end of 2019/early 2020 so as to feed the next EC work programs;
- The IP shall be endorsed by both the ETIP SNET Governing Board and – if possible – by the SET Plan IWG4 to give a better visibility and understanding of the RD&I framework relative to action 4 "Increase the resilience and security of the energy system".

Consequently, the present monitoring report will support the development of the next Roadmap/ Implementation Plan by providing detailed information regarding the degree of coverage of each RD&I item of the most recent 10-year RD&I roadmap 2017-2026.

[34] https://www.etip-snet.eu/etip-snet-vision-2050/

ANNEX 1 – ALLOCATION OF PROJECTS BY ACTIVITIES

The next table illustrates the allocation of the projects[35] depending on their inputs for the Transmission part and/or Distribution part of the RD&I item of the 10-year RD&I roadmap covering 2017-26.

Projects (FP7 / H2020[36] or Other projects[37])	Transmission	Distribution
ANYPLACE	T11	D1, D2, D10, D11
ARROWHEAD	T11, T13, T14, T15, T16, T17, T19, T20, T21, T22	D1, D2
CryoHub		
DREAM		D1, D8
eBADGE	T1, T5, T11, T15, T16, T19	D1, D2, D3, D9
ELSA		D5
EMPOWER		D1, D2
EU-SysFlex	T6, T9, T15, T17	
FLEXCOOP		D1, D2, D3, D10
FLEXICIENCY		D1, D2, D10
FLEXITRANSTORE	T1, T2, T3, T5, T6, T9, T10, T11, T12, T13, T15, T16, T17, T22	
Flexturbine		D14
FutureFlow	T9, T11, T12, T19, T21	
GOFLEX		D1, D2, D3, D5,D8, D10
GRIDSOL	T2, T3, T4, T5, T6, T7, T9, T10, T11, T12, T15, T16, T17, T18, T20, T22	
H2FUTURE	T10, T14	
iDistributedPV		
inteGRIDy		D1, D3, D5, D9
INTERFLEX		D1, D2, D3, D4, D5, D6,D7, D8, D9, D10, D11, D12, D13, D14
INTERPLAN	T1, T3, T4, T5, T10, T11	D3, D4, D5, D12
MIGRATE	T1, T5, T6, T9, T19	
NAIADES		
NETFFICIENT		D2, D3, D4, D8, D9, D10
NOBEL GRID		
OSMOSE	T5, T6, T7, T9, T10, T11, T12, T13, T15, T16, T17, T19	
PLAN4RES	T1, T5, T6, T10, T11, T13, T14, T22	

[35] The list of Project corresponds to the 121 projects identified in the first part of the monitoring activity published at the end of 2018 (https://www.etip-snet.eu/wp-content/uploads/2018/11/Project_monitoring_Part1-Final-.pdf)

[36] Co-funded by FP7 or Horizon 2020

[37] Funded by other instruments, in general at national or regional level. These projects might also benefit from EU funds, for instance from CEF, LIFE, ERDF or ERA-Net.

Projects (FP7 / H2020[36] or Other projects[37])	Transmission	Distribution
PlanGridEV		D3, D6, D12
PROME3THE2US2		
RealValue	T1, T2, T3, T4, T6, T9, T10, T14, T20	D1, D2, D3, D5, D7, D10
RESERVE	T2, T3, T5, T6, T7, T8, T9, T11, T12, T16, T17, T19, T20	D8, D9
SENSIBLE		
SHAR-Q		D3, D5, D6, D8
SMARTEREMC2		D1, D10
SMARTNET	T9	D1, D3, D4, D8, D9
SMILE		D2, D3, D5, D11
SOGNO		
STORE&GO		
SUCCESS		
SUNSEED	T1, T5, T6, T16, T21	D1, D9, D10, D11
TILOS	T10, T11, T12, T16	D1, D5, D9, D10
TURBO-REFLEX		D14
UPGRID		D1, D3, D6, D8, D10, D12, D13
WiseGRID		D1, D2, D3, D5, D6, D8, D10, D12, D13
3D DSS	T1, T4	
ADELE	T10	D4, D5
ADOSA	T1, T10	D5
ADVANCE DISPATCHING & LFOR	T7, T9	
ALEGRO	T4, T15	
ALISIOS	T10	
AMCOS	T6, T10	
AMPACITY		D12, D13
CECOVEL	T4, T11, T19	
CEDREN HydroBalance	T10, T12, T15	
CINELDI		
CITIES		
CLOUDGRID	T9, T10, T11, T16	D1, D5, D12
CO-RISE		
Cyprus RESGRID		
DC-Blocking Device		
DIGITALIZATION OF THE VIDIŠKIAI TRANSFORMER SUBSTATION	T19	
DLR	T13	
DS3	T9	
Dynamo		D1, D9, D10
EL Upgraded Biogas		

Projects (FP7 / H2020[36] or Other projects[37])	Transmission	Distribution
ELECTROGAS		
EL-TRAN		
Energy Data Service	T18, T19, T21	
FASAD		D9
FLEXITES	T22	
FLEXNETT		D1, D3, D5, D6, D8, D10, D11
Graciosa		
HEILA	T19	D3, D4, D5, D6, D8, D9
HVDC LINK	T6, T13	
Hybrid HVAC / HVDC overhead lines in Switzerland	T3	
Hybridised LAES	T9, T10	
IDEAS		
IHSMAG		D1
Integrated IT-Systems	T18, T19	
ITCITY		
KRYOLENS	T10, T15, T16, T22	
KWK-Flex		
LEAFS		
LIFE Factory Microgrid		D1, D2, D4, D5, D6
LIFE ZAESS	T10	D5
LIVING GRID	T5, T8, T9	
LVM		D8, D10, D11
MMC	T13	
MODFLEX		D1
NEDO	T3, T4, T5, T6, T8, T9, T10, T11, T12, T17, T19	D1, D2, D8, D9
NEXUS	T1, T3, T6, T8, T9, T10, T11, T12, T15, T17	D1, D3, D4
NOISEEK		D2, D10
OSIRIS		D13
Poste Intelligent		
Power Line Guardian / Tower Router	T6, T13	
Power Off and Save	T9, T11	
REDACTIVA		D8, D9
RENOVAGAS		D5, D7
SAVR		D3, D8
Schwungrad Rhode Hybrid Test Facility	T10,	
SECUREGRID	T21	D11
SINAPSE		D8, D10
SINCRO.GRID	T1, T5, T6, T12, T13	

Projects (FP7 / H2020[36] or Other projects[37])	Transmission	Distribution
SIREN	T1, T2, T5, T6,T7, T8, T9, T10, T11, T13	
SMART GRID BATTERY STORAGE PROJECT PROTTES	T6, T10, T15	D5
Smart Grid Gotland		D1, D3, D5, D8, D9
SMART SYNERGY		
SMARTER NETWORK STORAGE		D5, D12
SMARTPV		D1,D2, D10
STENSEA	T3, T6, T9, T10	D5
STORAGE LAB	T10, T17	
STORE		
STORES		D5, D8
STRONgrid		
SUBZERO		
SWARMGRID	T5, T9	
UGRIP		D1, D3, D5, D8
UNDERGROUND SUN STORAGE	T8, T9, T10, T14	
VAGE		
Variable Shunt Reactor		
WISE-PV		
WIVE		D4, D9

ETIP SNET

EUROPEAN TECHNOLOGY AND INNOVATION PLATFORM
SMART NETWORKS FOR ENERGY TRANSITION

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

www.etip-snet.eu