Minutes of stakeholder debates (lessons learned) for nine knowledge sharing workshops

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"Support to R&D strategy in the area of SET Plan activities in smart grids and energy storage"

Deliverable D4.1

by

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1 Introduction

1.1 Objectives of knowledge sharing

With the Grid+Storage service contract, knowledge sharing activities are gathered into work package 4 (WP4) "Extracting good practice and support knowledge transfer". The objectives of WP4 are:

- To extract good practices gained in pilots and demonstration activities,
- To support knowledge transfer from these projects to energy network operators, storage players and any other interested stakeholders.

To these objectives, knowledge sharing workshops are organised to emphasise the potential scaling and replication of the experimental or simulation results obtained during the RTD&D projects, and to protect intellectual property rights (IPR) by involving industry in the description of the project results in the existing Knowledge Sharing Platform (KSP) GridInnovation-online[1].

1.2 Organisation of knowledge sharing workshops

1.2.1 Regional approach

The initial approach adopted by Grid+Storage consisted in organising nine physical workshops per area of network operator activities (the "clusters" of the existing EEGI roadmap) with a specific focus on energy storage.

In August 2015, it was decided by the Grid+Storage consortium and approved by DG ENER to change this approach per cluster into a regional approach (workshops organised per group of Member States), with the objective of stimulating the participation from local or national projects rather than focusing on European projects.

The workshops are organised according to the schedule presented in Table 1 below.

Table 1 – Planning for the nine regional first knowledge sharing workshops

Workshop nr.	Member States	Location	Date
1	Belgium, France, Luxemburg, the Netherlands	Lille (France)	25-26 November 2015
2	Estonia, Latvia, Lithuania	Riga (Latvia)	12-13 January 2016
3	Denmark, *Norway*, Sweden, Finland	Helsinki (Finland)	26-27 January 2016
4	Bulgaria, Cyprus, Greece, Romania	Athens (Greece)	9 February 2016
5	Portugal, Spain	Madrid (Spain)	15-16 February 2016
6	Austria, Hungary, Slovakia, Czech Republic	Vienna (Austria)	24-25 February 2016
7	Croatia, Italy, Malta, Slovenia, *Switzerland*	Rome (Italy)	29 February – 1 March 2016
8	Germany, Poland	Munich (Germany)	9-10 March 2016
9	Ireland, UK	London (UK)	15 March 2016

[1] See http://www.gridinnovation-on-line.eu/.

The Grid+Storage workshops are organised in cooperation with the ERA-Net Smart Grids Plus initiative[2] in order to stimulate the participation of local stakeholders.

1.2.2 Programme of the knowledge sharing workshops

The nine workshops are held over between one and two days according to the agenda below (adjusted depending on logistical constraints and number of projects presented):

DAY 1

Morning (9-13:00)

- Introduction about the new SET Plan organisation
- Introduction about the future integrated R&I activities on Grid + Storage
- Regional Project # 1
- Regional Project # 2
- First round table about lessons learned by the attendees from the projects

Lunch break (13-14:00)

Afternoon (14-17:00)

- Presentation of the road-mapping process and the Knowledge Sharing Platform (TECHNOFI)
- Preparing the deployment of innovative solutions with ERA-Net Smart Grids Plus
- Regional Project # 3
- Regional Project # 4
- Second round table about lessons learned by the attendees from the projects

Networking dinner

DAY 2

Morning (8:30-11:00)

- Regional Project # 5
- Regional Project # 6
- Third round table about lessons learnt by the attendees from the projects

Wrap up of the workshop (11:30-13:00)

- Final round table animated by TECHNOFI with participation of projects representatives and members of EASE, EDSO for Smart Grids and ENTSO-E
    - Impacts of the new knowledge presented by the six projects onto the Grid and Storage roadmap
    - Recommendations for future R&I activities and regional investments about grid and energy storage solutions
    - Options for the tentative deployment plans of the described solutions and barriers to be overcome according to the ERA-Net Smart Grids Plus approach

Lunch break (13-14:00)

Afternoon

- Potential demo visit if feasible
- Projects prepare their labelling in direct with ERA-Net Smart Grids Plus and TECHNOFI

[2] See http://www.eranet-smartgridsplus.eu/.

1.3 Structure of this report

For each of the nine knowledge sharing workshops, this report gathers the following information:

- List of projects presented, including the link to the slides displayed at the workshop;
- Participants in the different roundtables;
- List of attendees[3];
- Minutes of the roundtables dedicated to the projects presented, with the main questions raised and topics of discussion;
- Summary of the lessons learned from the workshop (last roundtable).

2 Workshop 1 (Belgium, France, The Netherlands)

The first workshop was held in Lille (France) on the 25th and 26th of November, 2015. The workshop agenda is available on the Grid+Storage website.

2.1 Projects and participants in the workshop

2.1.1 R&I Projects presented

Six R&I projects were presented during the first workshop, as displayed in Table 2 below.

Table 2 – Projects presented at the first knowledge sharing workshop

Project	Country	Purpose	Speaker	Link to presentation
LINEAR	Belgium	Large-scale residential demand response project with 250 families in Flanders. The families have washing machines, dishwashers, tumble dryers, electric boilers, EV's and heat pumps. Dynamic pricing, portfolio balancing, voltage control are tested.	Pieter Vingerhoets, Project coordinator smart grids and ICT applications, KU Leuven / EnergyVille	Link
Pampus Project	the Netherlands	Demonstration on the Pampus Island of second life usage by the DSO of used car batteries at households with solar panels.	Haike van de Vegte, Senior Consultant New Energy Technologies, DNV GL Energy	Link

[3] Only the attendees having agreed to have their names listed in the minutes of the workshops are included.

Smart Substation	France	Innovative solutions bringing new functionalities and complete substation digitizing (electrical, mechanical, environmental data)	Thierry Buhagiar, Project coordinator, RTE	Link
GREDOR	Belgium	Addresses challenges in the management of distribution systems raised by the integration of renewable energy sources and new consumption practices, from investment decisions to real-time control.	Damien Ernst, Professor, Holder of the EDF-Luminus Chair on Smart Grids, Université de Liège	Link
VENTEEA	France	Improve the hosting capacity for renewable energies on the medium voltage network	Didier Colin, VENTEEA Project Manager, ErDF	Link
AES Advancion Energy Storage Array	the Netherlands	Commercial installation of 10 MW Li-ion batteries connected to the transmission network of TenneT NL.	Steve Corwell, AES Europe Vice President, The AES Corporation	Link

2.1.2 Roundtables

Four roundtables were held during the workshop, all facilitated by Serge Galant, Chairman of Grid+Storage Steering Board. The first three were mainly devoted to questions for the representatives of the projects presented. The fourth one, gathering also representatives from EASE, EDSO for Smart Grids and ENTSO-E, aimed at summarizing the debates and extracting the lessons learned from the workshop. Table 3 below shows the participants in each roundtable.

Table 3 – Participants in roundtables at the first knowledge sharing workshop

Roundtable nr.	Participants
1	• Henrik Dam, Policy Officer New energy technologies and clean coal, DG ENER, European Commission • Pieter Vingerhoets, Project coordinator smart grids and ICT applications, KU Leuven • Haike van de Vegte, Senior Consultant New Energy Technologies, DNV GL Energy • Eric Peirano, Grid+Storage Project Manager, TECHNOFI
2	• Thierry Buhagiar, Project coordinator, RTE • Damien Ernst, Professor, Holder of the EDF-Luminus Chair on Smart Grids, Université de Liège • Eric Peirano, Grid+Storage Project Manager, TECHNOFI

3	• Didier Colin, VENTEEA Project Manager, ErDF • Steve Corwell, AES Europe Vice President, The AES Corporation • Eric Peirano, Grid+Storage Project Manager, TECHNOFI
4	• Maria-Laura Trifiletti, EASE • Steve Corwell, The AES Corporation, representing EASE • Victoria Gerus, EDSO for Smart Grids • Norela Constantinescu, ENTSO-E • Iva Gianinoni, RSE, representing also ERA-Net Smart Grids Plus Support Team • Bart Mantels, VITO / EnergyVille

2.1.3 List of attendees

In total the workshop was attended by 36 participants, listed in Table 4 below.[4]

Table 4 – Attendees in the first knowledge sharing workshop

Name	Company
Antoine Besson	Bouygues Energies & Services
Christian-Eric Bruzek	Nexans France
Thierry Buhagiar	RTE
Claude Campion	3C Projects
Didier Colin	ErDF
Norela Constantinescu	ENTSO-E
Bertrand Cornélusse	Université de Liège
Steve Corwell	AES EUROPE / EASE
Henrik Dam	European Commission
Bart De Meyer	Eandis
Sophie Dourlens-Quaranta	TECHNOFI
Damien Ernst	Université de Liège
Bruno Francois	Ecole Centrale de Lille - L2EP
Serge Galant	Technofi
Victoria Gerus	EDSO for Smart Grids
Iva Maria Gianinoni	RSE
Victor Gomes	ENERCON GmbH
Cristina Gómez	REE
Vassilis Iliadis	AES Technologies
Bart Mantels	VITO / EnergyVille
Marcel Meeus	Sustesco bvba
Alexandre Parisot	RTE
Eric Peirano	Technofi
Benoit Robyns	Hautes Etudes d'Ingénieur
Janailson Rodrigues	SuperGrid Institute
Johan Steimes	Université Libre de Bruxelles

[4] Only the attendees having agreed to have their names listed in the minutes of the workshops are included.

Marion Steward	EDF
Cédric Thoma	French Ministry of Energy
Gilles Tihon	SPF - Public Service of Wallonia
Maria Laura Trifiletti	EASE
Ruud Van de Meeberg	Enexis BV
Haike Van de Vegte	DNV GL Energy
Gérald Vignal	RTE
Pieter Vingerhoets	ENERGYVILLE - KU Leuven
Conor Wilson	Gaelectric Energy Storage

2.2 Minutes of the debates

2.2.1 Roundtable 1

Questions about the Grid+Storage process to Eric Peirano (TECHNOFI)

- The change in approach between the existing EEGI roadmap and the upcoming Grid+Storage integrated R&I roadmap (RIR) was questioned. It was made clear that the main change is the focus on R&I activities relative to energy storage integration in the power system. An additional change will be the structure of the RIR which should improve readability.
- A question was raised about how to address dissent between stakeholders during the consultations process. The example of micro-grids was taken to illustrate diverging views amongst the smart grids and energy storage community. It is also the role of monitoring and knowledge sharing to provide experience feedback about each type of approaches and technologies. No option shall be discarded for R&I activities except if it has been proven that it is not promising. The project's partners have proposed a dissent management methodology (Deliverable 1.1).
- Clarification was requested since the Grid+Storage contract is supposed not to address batteries. It was made clear that Grid+Storage addresses the integration to the grid of all types of energy storage solutions (including batteries and also power to gas technologies which allow to connect gas and electricity networks); but it does not address R&I activities about battery (or power to gas) technologies such as new materials to improve performances (efficiency, ageing, etc.).
- About the knowledge sharing platform (KSP), it was asked whether data sets could be uploaded to it. It was answered that even though the KSP has not been designed to that purpose, this could be possible. It is currently under discussion in the framework of the eHighway2050 project for a data base relative to transmission technologies (cost and performances).

Questions to Henrik Dam (EC, DG ENER)

- It was asked whether grid operators would be allowed to operate energy storage facilities in the future. Henrik Dam said that the matter is being considered by the European Commission in the context of the energy market design consultation and the proposals for the revision of the Third Energy Package expected by Dec. 2016. In his opinion, the probable scheme would be that grid operators buy services to energy storage operators. For some specific purposes (for instance black-start capabilities), allowing TSOS/DSOs to own the energy storage assets has yet to be decided yet.

- The need for research about regulation to reach the objective of a single energy market covering the 28 Member States (MS) was pointed out. Henrik Dam replied that this is an ongoing process: for instance, MS have to share their development plans; a regional approach to balancing is currently under discussion. In general, R&I projects could challenge existing regulations. For example, in some demonstration projects, DSOs are owning storage assets. The only regulations which cannot be disregarded are the safety regulations.
- Another question was raised about the standards for manufacturers.

Questions to Haike van de Vegte (DNV GL Energy) about the Pampus project

- With the main difference between centralised and decentralised storage being the maintenance costs, it was asked if maintenance costs have been evaluated for the Pampus project; and if these costs are increased because of the second-life use of batteries. More generally, life cycle costs of batteries have to be assessed.
- The status of primary reserve granularity was raised (between 15 and 60 minutes).
- The replicability of the Pampus project was questioned. Is it limited by the supply of second-life batteries? Haike van de Vegte replied that the fleet of electric vehicles (EV) is growing fast. The market for batteries from cars that can be used for second life application shall become serious in 2020 in DNV GL's predictions. In addition, second-life batteries are one of the solutions amongst other storage technologies (including new batteries).
- What about the security aspects of the battery? It is built in containers and a safety protocol developed in the STALLION project[5] is applied.
- The battery management system (BMS) needed to address different types of batteries, with different ages, was discussed.
- How to ensure the capacity of batteries was questioned.
- The issue of the ownership of second-life batteries was raised. In principle the car manufacturer is responsible for recycling the batteries. This legal responsibility can be transferred for a demo project.

Questions to Pieter Vingerhoets (KU Leuven) about the LINEAR project

- Recommendations about regulation were discussed.
- It was asked whether specific R&I activities about demand response (DR) in large industries would be included in the roadmap, complementing residential DR.
- How storage for hot water tanks can be taken into account was discussed. The RealValue project (Ireland) was mentioned.
- The need for automated activation of DR was pointed out, because consumers on the long run cannot realistically be active in a manual manner.
- The motivation of consumers to participate in DR out of a demonstration project was questioned. Pieter Vingerhoets said that 3 main motivations exist: 1) enthusiastic to help; 2) comfort; and 3) money: but for the moment the business case is not here; cost of smart appliances need to decrease.
- The competition between energy efficiency and active consumption was discussed: the more the devices are energy-efficient, the less there is an interest in demand response. More generally, market-based solutions vs. obligations for DR were discussed.
- It was asked whether residential DR could participate in voltage control in Europe. Pieter Vingerhoets answered positively but said that it would not be the main driver.

[5] "Safety Testing Approaches for Large Lithium Ion battery systems".

2.2.2 Roundtable 2

Questions to Thierry Buhagiar (RTE) about the smart substation project and to Damien Ernst (Université de Liège) about the GREDOR project

- A question was raised on the possible roll out of smart substations both at the TSO and DSO levels, and more especially how to use the RTE concept in the GREDOR approach for DSOs? Damien Ernst said that the historical split between TSOs (well monitored and controlled part of the system) and DSOs (part of the system with less monitoring and control capabilities) was not valid anymore, because today we need the DSOs to be equipped with smart substations. Thierry Buhagiar pointed out that many issues needed to be solved before the complete roll out of smart substations in the network: first the level of decentralised control (functions which are completely automated versus functions which remain in the hands of the operators) and the control of the system seen from the TSO (how the different automated systems could interact and generate dynamics that the operators cannot handle). If such issues can be solved, the next challenge would be to share data and have a common model since the TSOs could need to communicate with distributed power generation and large pools of consumers through DSOs: a real-time communication system would need to be created.
- Questions were raised on the profitability of the wide roll out of storage devices in distribution networks. According to Damien Ernst, storage investments would make the distribution system more efficient by avoiding too sophisticated solutions and reinforcement.
- Discussions focussed on the overall profitability of storage in the power system. Many remarks were made arguing that, except for the projects advertised by some companies such as AES, it is still difficult to find profitable applications, except when addressing multiservice applications as recommended by some players. It was pointed out that pumped hydro storage (PHS) in Germany is no longer profitable since the daily market spread has decreased because of PV production. Some attendees pointed out that beyond the perspective offered by integrators such as AES, the domestic battery marketed by Tesla (power wall) should also change the storage market: PV systems with batteries should be competitive shortly. This point opened the debate for the costs that should be charged by network operators in the case of a wide roll out of self-consumption schemes.

2.2.3 Roundtable 3

Questions to Didier Colin (ErDF) about the VENTEEA project and to Steve Corwell (AES Europe) about the AES project

- TSOs and DSOs should seek for the lowest cost for society of storage solutions compared to grid upgrade; it was asked how far we are today (in years or in euros) from this minimal cost. Didier Colin said that such study has been done: there is no advantage for storage except for some cases in substations for multiservice applications (in general for a few hours, and in urban areas). In addition, TSOs/DSOs shall call upon the market to provide services. Steve Corwell (SC) said however, that regulators base their decisions upon cost-benefit analyses (CBA): if storage is cheaper, regulators will allow it.

- Following several questions regarding the profitability of the AES systems, Steve Corwell replied that the company had found at least three business applications: PCR (primary control reserves), replacement reserves (in lieu of power plant derates) and longer duration flexible peaking. SC pointed out that the company is investigating other applications that are now competitive and will become even more so since the cost of batteries should continue to decrease in the coming years due to a significant increase of the manufacturing capacities in the world to meet EV demand. SC explained that AES has developed an integration approach which allows the scaling (up and down) of the systems to accommodate various grid needs and with different batteries and battery providers.
- About the real electrical efficiency of the batteries, Didier Colin said that it was difficult to assess, since it depends on the services provided (ErDF promotes a multiservice business model). Steve Corwell added that there are some issues about the building codes (isolation is mandatory in buildings hosting the batteries while cooling is necessary for the batteries to maintain their performances in time).
- The comparison between batteries and power-to-gas solutions was discussed. It was explained that these two technologies provide different services to the power system at different scales. Power to gas are conversion technologies (from electricity to gas) which allow to store electricity in the form of chemical energy which in turn is easy to store in large quantities (natural gas network). This gas can be used for heating (connection with heating networks), electricity generation in gas turbines, in industry, in the transport sector for instance. Batteries are used for electricity to electricity applications.
- A comment was made regarding the fast penetration of power electronics on the network which could cause stability problems (frequency control for instance) following a discussion on the possible large scale deployment of batteries in the power system.

2.3 Lessons learned from the workshop

These lessons and recommendations have been discussed and agreed upon during the 4th roundtable.

2.3.1 Impacts of the new knowledge presented by the six projects onto the GRID+STORAGE roadmap

The projects presented covered a large range of maturity levels for network operators, from TRL 5 for some applications to TRL 9 for some others.

Storage as a flexibility option will impact the following TSO and DSO clusters in the roadmap:

- Planning,
- Operations,
- Asset management,
- Market design.

2.3.2 Recommendations for future R&I activities and regional investments about grid and energy storage solutions

One first recommendation is that "clean" large scale demonstrations are needed, involving cost-benefit analyses and life cycle assessments. Such demonstrations should involve regulatory bodies and address small scale dispersed storage functionalities.

At DSO level, there is a clear need for support tools for decision making on flexibility management.

2.3.3 Options for the tentative deployment plans of the described solutions and barriers to be overcome

The following topics need to be addressed in the future roadmap:

1. Regulatory harmonisation on storage,
2. Knowledge sharing on demonstrations,
3. Business good practices (from product specification to competitive procurement) to turn energy storage and other demonstration technologies into viable business activities,
4. Valuation of storage as a multi-service solution,
5. Ownership of storage,
6. Standardisation of grid connected energy storage,
7. Clean CBA including LCA approaches,
8. Taxes and fees that puts pressure on the real value of energy storage solutions.

2.4 Projects willing to join the Knowledge Sharing Platform

The following stakeholders have expressed willingness to join the knowledge sharing platform GridInnovation-online.

- CAES (Ireland),
- Université Libre de Bruxelles,
- Université de Liège for the GREDOR project,
- AES energy storage arrays,
- EnergyVille for the LINEAR project (with updated results).

3 Workshop 2 (Estonia, Latvia, Lithuania)

The second workshop was held in Riga (Latvia) on the 12th and 13th of January, 2016. The workshop agenda is available on the Grid+Storage website.

3.1 Projects and participants in the workshop

3.1.1 R&I projects presented

Seven R&I projects were presented during the first workshop, as displayed in Table 5 below.

Table 5 – Projects presented at the first knowledge sharing workshop

Project	Country	Purpose	Speaker	Link to presentation
DSM Platform for Optimal Energy Management Strategies Development	Latvia	Experimental rational use of energy with aim to demonstrate and simulate the potential of smart meters and home area network automation implementation and their interoperability with energy management strategies	Artjoms Obushevs, Researcher, Institute of Physical Energetics	Link

Energy Storage Application in Urban Electric Transport	Latvia	Recuperation of tramway braking energy by equipping substations with reversible rectifiers and installing energy storage devices	Linards Grigans, Researcher, Institute of Physical Energetic	Link
Smart Energy Management System with Energy Storages	Estonia	Overview of two different pilot systems in Tallinn University of Technology: 1. Smart Energy systems - AC/DC Link Based Microgrid System for Research and Study Purposes, and 2. Load Management System – Day-Ahead Electricity Price Based Energy Management System	Argo Rosin, Senior Research Scientist / Vice-Dean for Research, Department of Electrical Engineering / Faculty of Power Engineering, Tallinn University of Technology	Link
Development of a Li-Ion Energy Storage System for Electrical Microgrids	Estonia	Design and construction of a 150 kW Li-Ion energy storage system (ESS) prototype; development of control algorithms and methodology	Tarmo Korõtko, PhD student, Department of Electrical Engineering, Tallinn University of Technology	Link
Smart Electric Thermal Storage (RealValue project)	Latvia	Deployment of Smart Electric Thermal Storage (SETS) at 50 locations in Latvia (homes and commercial buildings); cost-benefit analysis and business plan development	Zane Broka, PhD student, Riga Technical University	Link
Large-Scale Electrical Energy Storage Potential in the Baltic States	Latvia	Analysis of the potential demand for energy storage in the Baltic States; large- and small-scale technologies comparison	Karlis Baltputnis, PhD student, Riga Technical University	Link

Estfeed data sharing platform	Estonia	Software platform capable to integrate many data sources and to provide appropriate services to convert these data into valuable information for energy flexibility management, energy efficiency, audit and benchmarking	Kalle Kukk, Strategy Manager, Elering	Link

3.1.2 Roundtables

Four roundtables were held during the workshop. The first three were mainly devoted to questions for the Speakers and interactions with the audience about the lessons learnt by the projects and the new knowledge needs to better integrate energy storage into the electricity system. The fourth roudtable, gathering also representatives from the ERA-Net Smart Grids Plus support team, EASE and ENTSO-E, aimed at measuring the impacts of the new knowledge presented by the seven projects onto the Grid and Storage roadmap and summarizing the recommendations for future R&I activities and regional investments about grid and energy storage solutions.. Table 6 below shows the participants in each roundtable.

Table 6 – Participants in roundtables at the first knowledge sharing workshop

Roundtable nr.	Participants
1	• Artjoms Obushevs, Institute of Physical Energetics • Linards Grigans, Institute of Physical Energetic • Eric Peirano, TECHNOFI (moderator)
2	• Argo Rosin, Tallinn University of Technology • Tarmo Korõtko, Tallinn University of Technology • Eric Peirano, TECHNOFI (moderator)
3	• Zane Broka, Riga Technical University • Karlis Baltputnis, Riga Technical University • Kalle Kukk, Elering • Eric Peirano, TECHNOFI (moderator)
4	• Zane Broka, Riga Technical University • Karlis Baltputnis, Riga Technical University • Kalle Kukk, Strategy Manager, Elering • Norela Constantinescu, ENTSO-E • Allan Schrøder Pedersen, EASE • Eric Peirano, TECHNOFI (moderator)

3.1.3 List of attendees

In total the workshop was attended by 40 participants, listed in Table 7 below. [6]

Table 7 – Attendees in the second knowledge sharing workshop

Name	Company
Triin Aavik	Eesti Energia As
Ott Antsmaa	Elektrilevi OÜ
Karlis Baltputnis	Riga Technical University
Viesturs Brazis	Riga Technical University
Zane Broka	Riga Technical University
Jānis Černovs	AS "Sadales tīkls"
Vladimir Chuvychin	Riga Technical University
Norela Constantinescu	ENTSO-E
Laimonas Dapsys	Modus Energija
Sophie Dourlens Quaranta	TECHNOFI
Dainis Dravnieks	Ministry of Economics
Juris Flugins	AS "Sadales tīkls"
Helena Geissler	B.A.U.M. Consult
Juris Golunovs	Riga Energy Agency
Larisa Grackova	Institute of Physical Energetics
Ervins Grebesh	Institute of Physical Energetics
Linards Grigans	Institute of Physical Energetics
Ivo Grinbergs	AS "Sadales tīkls"
Polina Ivanova	AS Latvenergo
Leo Jansons	WEC LMC
Tarmo Korõtko	Tallinn University of Technology
Kalle Kukk	Elering AS
Olegs Linkevics	Latvernergo
Bart Mantels	VITO / EnergyVille
Anna Mutule	Institute of Physical Energetics
Artjoms Obusevs	Institute of Physical Energetics
Irina Oleinikova	Institute of Physical Energetics
Eric Peirano	TECHNOFI
Andrejs Roscins	Energokomplecss
Argo Rosin	Tallinn University of Technology
Ivars Rozenštrauhs	AS "Sadales tīkls"
Allan Schroeder Pedersen	Technical University of Denmaark
Antanas Sauhats	Riga Technical University
Gunta Šlihta	IPE
Girt Stana	Riga Technical University

[6] Only the attendees having agreed to have their names listed in the minutes of the workshops are included.

Diana Zalostiba	Riga Technical University

3.2 Minutes of the debates

3.2.1 Roundtable 1

Questions about the Grid+Storage process to Eric Peirano (Technofi)

- Following a question raised by an attendee, it was made clear that all types of energy storage technologies are considered in the roadmap (not only electrochemical storage). The focus indeed is on the integration of energy storage to the grid whatever the storage technologies are.
- It was also asked whether power plants capable to adapt their running regime to market conditions could be considered as energy storage. It was made clear that this shall be considered as a flexibility source, but this is not the main focus of the roadmap.

Questions to Artjoms Obushevs (Institute of Physical Energetics) about the DSM Platform

- The relation between DSM profitability and sufficient market price differentials was discussed, as well as automated activation of DSM versus active (manual) participation of consumers.
- Disconnection of load in case of high market prices was considered: it should be done locally and not at substation level.
- The concrete impacts of DSM in Latvia were discussed. For the moment, such impacts are difficult to assess: Latvia's consumption being quite low it is difficult to find a business case for DSM and only consumers with a yearly consumption higher than 2,500 kWh could provide DSM. However, the development of the Internet of Things (IoT) and consequently the decrease in the price of technologies to connect e.g. home appliances should foster the deployment of DSM. In addition, by 2023, 100% of Latvian consumers will be equipped with a smart meter and will have access to real-time consumption data. The participants agreed that DSM for industrial consumers should be addressed first.
- Combination of DSM, storage and auto-consumption was discussed: still, in Latvia, PV is not booming because prices of PV systems remain too high which make it difficult to find a business case for auto-consumption

Questions to Linards Grigans (Institute of Physical Energetic) about Energy Storage Application in Urban Electric Transport

- Benefits of the recuperation of tramway braking energy were highlighted not only for efficient operation purposes but also because it limits the need for building new substations when extending the tramway network.
- The replication value of the proposed solution was discussed and collaboration with other cities was suggested. So far only a tens of cities in Europe are equipped with such solution in urban electric transport, and some projects exist for railway.
- Storing the braking energy in the substation connecting the DSO and the tramway electric network (with a dedicated storage device such as batteries) and injecting it back to the distribution system may be beneficial, for instance for frequency control purposes. However, there would be some issues in terms of permitting (the system operator of the tramway electric network would be considered as a power generator), as well as in terms of power quality (harmonics) and hardware (bidirectional flows in the substation).

- Further research is needed, in particular regarding supercapacitor aging models (supercapacitors and batteries would be a suitable solution for the envisaged system services). The impact of temperature on the performance (life cycle analysis) is also a topic.

3.2.2 Roundtable 2

Questions to Argo Rosin (Tallinn University of Technology) about Smart Energy Management System with Energy Storages

- Profitability of storage systems with regards to price differentials was discussed. In particular, transmission costs avoided thanks to local storage should be taken into account to improve profitability.
- It was highlighted that price differentials are not sufficient to assess profitability: the whole trajectory of the spot price must be taken into account.
- It was mentioned that the increase of stochastic power generation could cause higher and more frequent spot price fluctuations. Increased stochastic power generation will also influence the power quality in the grid, which means higher demand and cost for balancing (or other ancillary) services. This could also increase the feasibility of storage systems.
- Combination of storage systems with load management systems could increase the cyclic lifetime (and feasibility) of storage devices.

Questions to Tarmo Korõtko (Tallinn University of Technology) about the Development of a Li-Ion Energy Storage System for Electrical Microgrids

- It appears that a "universal use case" (applicable to households, factories, etc.) is infeasible within today's market conditions.
- The multiservice business model of batteries was discussed: they could be used for stabilizing power coming from RES generators but also for frequency control, fast reserve, etc. A multiservice business model (as discussed during the first workshop in Lille) would help to find a competitive business case for electrochemical storage. According to Elering, this type of storage clearly has a role to play for TSOs (new products, mFRR, etc.) and should be operated by other stakeholders.
- The use of second life batteries was identified as a promising solution to keep costs down.
- The impact on network tariffs of storage and auto-consumption deployment has been discussed, in particular for distribution network operators. New remuneration schemes for DSOs (based on capacity rather than on energy) may have to be found.

3.2.3 Roundtable 3

Questions to Zane Broka (Riga Technical University) about Smart Electric Thermal Storage (SETS)

- Profitability of sophisticated solutions like SETS and aggregation was questioned mainly by DSOs, compared to simple day/night signals sent to usual water boilers. It was highlighted that today, SETS are more profitable than other storage technologies. Automated activation is an important feature to guarantee the profitability.
- The role of the aggregator, and the possible impact of aggregated storage devices on congestion management were discussed (both in terms of volume and spatial distribution).
- Upscaling potential was questioned: simulation of SETS deployment with different energy scenarios is to be done both for planning and operation purposes, as well as behavioural studies.

Questions to Karlis Baltputnis (Riga Technical University) about Storage Potential in the Baltic States

- Modelling of weather correlation between Nordic and Baltic regions was identified as a key issue for smooth market integration.
- Suitable market incentives to develop storage were discussed. They could be similar to Feed-in-Tariffs for RES to ensure enough revenues for storage owners. Not only investment costs should be considered but also operation costs (for example efficiency of PHS is 70%: it is profitable only if price differentials are greater than 30%). To increase revenues of storage owners, price arbitrage must be complemented by provision of reserves.
- The question of central vs. decentralised accumulation was discussed: actually both would be useful and complementary.

Questions to Kalle Kukke (Elering) about the Estfeed platform

- Realistic deployment of DSM for households was questioned, since their consumption is considered as quite inelastic. Dynamic pricing would be a prerequisite.
- Legal issues may be raised for aggregators accessing the platform: they need to be authorised by the consumers. An important feature for the platform is to be operated by a neutral player (the TSO).

3.3 Lessons learned from the workshop

These lessons and recommendations have been discussed and agreed upon during the 4th roundtable.

3.3.1 Impacts of the new knowledge presented by the six projects onto the GRID+STORAGE roadmap

The projects presented cover a large range of maturity levels for network operators, from TRL 4-5 for some applications to TRL 9 for some others

Storage as a flexibility option will impact the following TSO and DSO clusters in the roadmap:

- Operations,
- Asset management,
- Market design.

3.3.2 Recommendations for future R&I activities and regional investments about grid and energy storage solutions

The following R&I activities must be considered in the roadmap:

- Business model for storage with multiple services;
- Second-hand automotive battery for stationary applications;
- Storage in transport electricity network located in substations to provide system services to DSOs;
- Home area network monitoring and control as a mean to promote DSM (price of automation and control expected to strongly decrease);
- Use of automated local thermal energy storage devices (consumer level) by aggregators so as to provide system services for network operators;
- Design market incentives together with taxes and fees for the integration of medium to large-scale storage (price signals);
- Dynamic price signals as a mean to stimulate demand response;
- Network reinforcement (interconnections) as a way to ease market integration

3.3.3 Options for the tentative deployment plans of the described solutions and barriers to be overcome

The following topics need to be addressed in the future roadmap:

- Open source software and open hardware;
- Interdependence of gas and electricity networks, i.e. for heating (not only heat networks but also decentralised Power-to-Heat devices);
- Services provided by DSM and storage to not only to DSOs but also TSOs;
- Data sharing and availability, use of ICT tools

3.4 Projects willing to join the Knowledge Sharing Platform

The following stakeholders have expressed willingness to join the knowledge sharing platform GridInnovation-online.

- Estfeed project (Estonia).

4 Workshop 3 (Denmark, Norway, Sweden, Finland)

The third workshop was held in Helsinki (Finland) on the 26th and 27th of January, 2016. The workshop agenda is available on the Grid+Storage website.

4.1 Projects and participants in the workshop

4.1.1 R&I projects presented

Six R&I projects were presented during the third workshop, as displayed in Table 8 below.

Table 8 – Projects presented at the third knowledge sharing workshop

Project	Country	Purpose	Speaker	Link to presentation
Smart Integrated Energy Storage	Sweden	Present the EnergyHub solution, a patented, market ready, 4-quadrant inverter for PV, storage, small scale wind and EV charging which adds value through a cloud business platform enabling savings.	Björn Jernström, CEO, Ferroamp	Link
Helen Ltd 1 MW storage in the Kalasatama-area	Finland	Present a large BESS system for network applications (primary / secondary frequency regulation, peak power shaving and voltage support).	Janne Huvilinna, Smart Grid Team, Helen Ltd	Link

Power-to-Gas via Biological Catalysis (P2G-BioCat)	Denmark	Present the BioCat power2gas pilot based upon an alkaline electrolysis and a biological methanation.	Markus Forstmeier, VP Business Development, Electrochaea	Link
Energy Storage – Storage related grid integration work in national projects in Finland	Finland	A presentation by VTT about the main nationally-funded smart-grid projects in Finland with a storage integration component.	Hannele Holttinen, Principal Scientist, VTT	Link
Large battery systems to stabilise frequency output from wind farms and for provision of primary reserve power	Denmark	Feedback from Vestas on field experience with storage to provide primary reserve for wind power farms.	Rasmus Lærke, Plant Control Systems Manager, Vestas.	Link
Large scale balancing from Norwegian hydropower	Norway	Explain to the audience the large-scale balancing opportunities offered by the Norwegian hydropower energy storage facilities.	Atle Harby, CEDREN Director, SINTEF Energy Research	Link

4.1.2 Roundtables

The first three roundtables were mainly devoted to questions for the representatives of the presented projects. The fourth one, gathering also representatives from EASE and EDSO aimed at summarizing the debates and analysing the impacts of the six presented projects onto the R&I topics to be selected in the integrated roadmap.

Table 9 below shows the participants in each roundtable.

Table 9 – Participants in roundtables at the third knowledge sharing workshop

Roundtable nr.	Participants
1	• Björn Jernström, CEO, Ferroamp • Janne Huvilinna, Smat Grid Team, Helen Ltd • Eric Peirano, Project Manager of Grid+Storage, TECHNOFI
2	• Markus Forstmeier, VP Business Development, Electrochaea • Hannele Holttinen, Principal Scientist, VTT

	• Rasmus Lærke, Plant Control Systems Manager, Vestas • Eric Peirano, Project Manager of Grid+Storage, TECHNOFI
3	• Atle Harby, CEDREN Director, SINTEF Energy Research • Eric Peirano, Project Manager of Grid+Storage, TECHNOFI
4	• All participants (plenary discussion) • Eric Peirano, Project Manager of Grid+Storage, TECHNOFI

4.1.3 List of attendees

In total, the workshop was attended by 37 participants, listed in Table 10 – below. [7]

Table 10 – Attendees in the third knowledge sharing workshop

NAME	COMPANY
Satu Paiho	VTT Ltd
Eric Peirano	TECHNOFI
Daniel Hernández Maldonado	TECHNOFI
Janne Huvilinna	Helen Ltd.
Bart Mantels	VITO / EnergyVille
Rasmus Laerke	Vestas Wind Systems
Teija Laitinen	CLIC Innovation
Hannu-Pekka Hellman	Helen Electricity Network Ltd
Tomas Qvickström	Fortum Power and Heat Oy / Production Optimization and Trading
Ville Tikka	Lappeenranta University of Technology
Kari Maki	VTT
Aira Hast	Aalto University
Sirpa Repo	Elenia Oy
Olli Huotari	Empower IM
Atle Harby	SINTEF Energy Research
Sebastian Johansen	Fortum
Jukka Rinta-Luoma	University of Vaasa
Marja Englund	Fortum Oyj
Hannele Holttinen	VTT
Behnam Zakeri	Aalto University
Conor Wilson	Gaelectric Energy Storage
Michael Child	Lappeenranta University of Technology
Kauko Leiviskä	University of Oulu
Juha Ulvinen	Eaton Power Quality
Juha Kuuluvainen	Eaton Power Quality
Allan Schroeder Pedersen	Technical University of Denmaark
Nosizwe Dlengezele	Hitachi Chemical Europe
Alexander von Jagwitz	B.A.U.M. Consult GmbH
Iva Maria Gianinoni	RSE
Antti Keskinen	Caruna
Björn Jernström	Ferroamp Elektronik AB
Juha Forsström	VTT

[7] Only the attendees having agreed to have their names listed in the minutes of the workshops are included.

Ludwig Karg	B.A.U.M.
Robert Weiss	VTT Technical Research Centre of Finland
Jussi Matilainen	Fingrid Oyj
Pekka Koponen	VTT technical Research Centre of Finland
Markus Forstmeier	Electrochaea

4.2 Minutes of the debates

4.2.1 Session 1

Questions/discussions following the presentation of Björn Jernström, CEO, Ferroamp

- The regulation relative to storage projects at LV level in Sweden (and Finland) were discussed: there are numerous limitations and Björn Jernström considered that companies must advertise the benefits of distributed storage systems, for instance the increase of grid flexibility.
- The aggregation of distributed storage to participate in frequency regulation markets was debated. Major challenges identified are relative to business plan opening opportunities for multiservice models, such as as voltage control, and data security when implementing large-scale deployment. Regarding possible revenues for storage solutions, it was argued that wind and PV power integration would increase the volatility of electricity prices in the future, thus making it more difficult to build business models on price trajectories.

Questions/discussions following the presentation of Janne Huvilinna, Smat Grid Team, Helen Ltd

- Technical performances of the Toshiba batteries were discussed (theoretical maximum number of cycles versus the investment costs). It was argued that if the lifespan of the batteries were not as specified by the vendor, it would be very difficult to find profitable business opportunities.
- Janne Huvilinna explained that the purpose of the project is to test different business opportunities for such systems, for instance primary/secondary frequency regulation, peak power shaving and voltage support. It was explained that such a system could be used in a portfolio of generation means to strengthen their bidding strategy on the market even though the most likely applications would be systems services. More generally, Helen Ltd is working on a long-term evaluation of these systems and a collaboration with DSOs is envisaged.

4.2.2 Roundtable 1

- During this session, business cases for (small-scale to medium scale) BESS were commented: there was a broad consensus around the multiservice business case of BESS, i.e. several applications should be combined in order to be reach profitability in competitive market conditions. Such applications should focus on the technical specificities of batteries (fast response) which call for a participation in frequency regulation. It was also pointed out that the scale of the systems and their spatial distribution in the network is a key point to optimise possible revenues.
- Investment and O&M costs fees were commented: it was suggested that a multiple owner scheme could help to enhance the integration of storage. It was suggested to put some R&D effort on BoS (including integration components) since they tend

to be as expensive as the batteries. Another way to lower investment costs could be to resort to second-life batteries: the participants stressed that a major issue is to evaluate with great accuracy the SoH (state of health). Most participants agreed to say that with the massive deployment of EVs, the price of the cells would probably drop to a price level that would make first-hand BESS profitable.

- Along with R&D activities to lower the costs of integration, the experts pointed out the need to incentivise the use of storage as it was done during the two last decades for wind and PV power. Moreover, regulations related to the ownership of such systems by regulated and market players should be rapidly clarified.

4.2.3 Session 2

Questions/discussions following the presentation of Markus Forstmeier, VP Business Development, Electrochaea

- Most of the discussions were related to the technical performances of the process and the scalability: how to valorise the wasted heat (low enthalpy) imposed by the optimal working temperature for the microorganisms? Markus Forstmeier explained that one very positive aspect of this technology is the handling of hydrogen which is consumed during the electrochemical process and not stored. Maintenance and operations of such processes were questioned: the technology has indeed a very high CAPEX but the OPEX expenses should be low, which should make it a competitive power2gas technology.

Questions/discussions following the presentation of Hannele Holttinen, Principal Scientist, VTT

- Most discussions focussed on the relative value of flexibility sources (slide 4 in the presentation). Hannele Holttinen mentioned that pump hydro current prices were taken into account in the calculations. Incentives to promote storage integration were proposed based on the available models.

- The flexibility provided by the Norwegian hydro facilities was discussed. It was stressed that the necessary reinforcements of the Norwegian transmission network so as to supply the new links to Holland, Germany, Denmark and the UK start to meet public acceptance issues in Norway. Moreover, it was argued that today there is no proven profitability for demand-response (only in few particular cases for industrial customers).

Questions/discussions following the presentation of Rasmus Lærke, Plant Control Systems Manager, Vestas.

- Storage life-time issues were discussed, i.e. how the patter of the different discharging and charging cycles would affect the batteries' lifespan since the number of cycles in a critical factor for profitability and therefore business models. Vestas mentioned that they currently base their investment decisions on the lifespan specified by the manufacturers.

- Rasmus Lærke explained that wind power and storage coupling is still not profitable in Europe because of the insufficient spread.

4.2.4 Roundtable 2

- The main messages were relative to regulations which should be changed to stimulate the development of BESS in the same way as it was done during the two last decades for renewables (feed-in tariffs). This would foster the creation of new

companies with innovative business models. All experts expect a strong reduction in the investment cost of batteries with the foreseeable development of EVs and the large-scale factories planned in China.

- The participants stressed that grid flexibility can be brought by other solutions than storage: network reinforcement, fast gas turbines, demand response, etc., and coupling with other energy networks where power2gas can provide a way to store large quantities of energy which can be used in other sectors such as transport, and possibly electricity and heat production in CHPs (but with a quite low electricity to electricity efficiency). Some participants argued that with the current prices of fossil fuels (gas), it could be difficult to find a market for power2gas technologies even with negative electricity prices.

4.2.5 Session 3 and roundtable 3

Questions/discussions following the presentation of Atle Harby, CEDREN Director, SINTEF Energy Research

- A study estimating the potential of the Norwegian hydropower for balancing and providing energy storage to the pan-European power system was presented (different scenarios depending of the penetration of renewables). It was shown that Norway alone could not provide all the necessary storage and flexibility (estimated to 150 TWh storage capacity in 2050 by IEA), but it could be a major player especially at time scales of several hours to a couple of weeks. It was stressed that more coordination between European TSOs would be required to use such resources: today, Nordic TSOs perform balancing activities for a single merged network. The Norwegian hydro and storage capacity was further discussed: Norway has few pumped hydro stations (seven up to now), but a large flexibility in storage hydro with 85 TWh in storage capacity. Studies have shown the potential to extend from current 30 GW to 50 GW of capacity by linking the different reservoirs. Norway could at least double its hydro capacity in the future with reliable business models. Atle Harby pointed out that social acceptance and environmental impact is now a major issue for hydro projects in Norway, but using only existing reservoirs would not cause large environmental impacts.

- The production costs of pumped hydro were discussed: it was concluded that Norwegian hydro power using existing reservoirs could be less costly than other technologies, even when costs for interconnectors across the North Sea to continental Europe and UK are included in addition to investments costs to link the reservoirs with new tunnels and power plants.

4.3 Lessons learned from the workshop

These lessons and recommendations have been discussed and agreed upon during the final roundtable.

4.3.1 Impacts of the new knowledge presented by the six projects onto the GRID+STORAGE roadmap

The projects presented during this workshop cover a high maturity level for network operators (TRL 7-9).

Storage as a flexibility option will impact the following TSO and DSO clusters in the roadmap:

- Operations,
- Asset management,

- Market design.

4.3.2 Recommendations for future R&I activities and regional investments about grid and energy storage solutions

The following R&I activities must be considered in the roadmap:

1) *Batteries: multiple services should be considered and demonstrated at different scales together with adapted business models and regulations.*
   - More business cases should be studied and evaluated.
   - Regulations have to evolve rapidly (incentives for example).
2) *Batteries and retail markets (access to flexibility markets).*
3) *Batteries: Social value for end users should be studied.*
   - Promote the social consciousness and provide high-quality services to end-users (auto consumption devices in Germany and the NEST thermostat in US)
   - Marketing and branding could be important tools to influence customer behaviour in order to help European decarbonisation.
4) *Data privacy issue for small scale storage.*
5) *New grid architectures integrated in the energy system and maximizing social welfare.*
   - Storage and local generation could challenge the TSO and DSO revenue models in the future.
   - TSOs and DSOs cooperation is fundamental for grid planning.
6) *Second-hand automotive battery for stationary applications: cost of BoS to be considered*
7) *Large-scale battery systems can be used for frequency controls (ancillary services) but business models and regulations must be adapted.*
8) *Power to gas of interest to couple grids with other energy (gas) networks for transport and heating applications. Power2gas technologies are still an issue.*
9) *Flexibility: DSM vs storage to be developed depending on cost trajectories.*
   - Important monetary costs for the transmission and distribution system.
10) *LV DC grids of interest to lower costs of BoS when coupling PV and storage (and other DC devices)*
   - Both economic and technical interests.
11) *Coupling wind power and battery systems: no obvious business models in well-meshed networks. Export potential for weak or isolated grids.*
12) *Good match between large-hydro in Norway and European wind production at affordable costs but transmission studies needed.*
   - Transmission constraints: stability, congestion, etc.
13) Power2heat for balancing and storage
   - Balancing power capacity (Germany and Austria examples)
   - Dynamic compensation between heat and electricity (heat with electricity when it is cheaper to do so).

4.4 Projects willing to join the Knowledge Sharing Platform

A general invitation to join the GridInnovation-online community and submit their respective projects was proposed to all the speakers and the workshop participants.

5 Workshop 4 (Bulgaria, Cyprus, Greece, Romania)

The fourth workshop was held in Athens (Greece) on the 9th of February, 2016. The workshop agenda is available on the Grid+Storage website.

5.1 Projects and participants in the workshop

5.1.1 R&I projects presented

Eight R&I projects were presented during the fourth workshop, as displayed in Table 11 below.

Table 11 – Projects presented at the fourth knowledge sharing workshop

Project	Country	Purpose	Speaker	Link to presentation
Hybrid stations: legal framework and regulatory aspects	Greece	Isolated island systems, a particularly favorable case for the application of storage through Hybrid Power Station (HPS): combination of RES units & energy storage devices with controllable generating units	Stavros Papathanasiou, Associate Professor, NTUA	Link
Lessons learned from the Ikaria hybrid station	Greece	Hybrid energy project on the Ikaria island combining wind generation and pumped hydro storage	Elias Spanos, Project Manager, ENET	Link
The Kythnos hybrid station	Greece	First worldwide bidirectional inverter installed and tested in the wind and solar PV hybrid system of Kythnos	John Chadjivassiliadis, Chairman of IENE (Institute of Energy for South-East Europe)	Link

Grid and Market Integration activities in Cyprus and the need for storage	Cyprus	Presentation of several projects in Cyprus including active demand management, distributed energy resources and energy storage	Ioannis Koumparou, Research Associate, PV Technology, FOSS Research Centre for Sustainable Energy, University of Cyprus	Link
FCH-JU Energy Storage Commercialization Study	Greece	Assessment of the role and commercial viability of energy storage (both power-to-power and conversion of electricity to heat and hydrogen) in light of the projected development of the European electric power system towards 2030 with an outlook to 2050	Christina Papadimitriou, Senior Researcher, NTUA	Link
Meltemi: microgrid concept in a holiday district	Greece	Video about the development of a microgrid	Aris Dimeas, Senior Researcher, NTUA	Link
Smart Islands networks with very high penetration of renewables	Greece	Demonstration of a new concept for islands: Hybrid station with oversized RES and small capacity of storage to increase the RES penetration beyond 60% while ensuring power supply	Aris Dimeas, Senior Researcher, NTUA	Link
Developing tools to increase RES penetration in smart grids	Greece	Proposition of control schemes with optimised network operation, active management of LV distribution networks and mitigation of overvoltage and of voltage imbalances	Grigoris Papagiannis, Professor, AUTH	Link

5.1.2 Roundtables

The first two roundtables were mainly devoted to questions for the representatives of the presented projects. The third one aimed at summarizing the debates and analysing the impacts of the eight presented projects onto the R&I topics to be selected in the integrated roadmap.

Table 12 below shows the participants in each roundtable.

Table 12 – Participants in roundtables at the fourth knowledge sharing workshop

Roundtable nr.	Participants
1	• Stavros Papathanasiou, Associate Professor, NTUA • Elias Spanos, Project Manager, ENET • John Chadjivassiliadis, Chairman of IENE (Institute of Energy for South-East Europe) • Ioannis Koumparou, Research Associate, PV Technology, FOSS Research Centre for Sustainable Energy, University of Cyprus • Eric Peirano, Project Manager of Grid+Storage, TECHNOFI
2	• Christina Papadimitriou, Senior Researcher, NTUA • Aris Dimeas, Senior Researcher, NTUA • Grigoris Papagiannis, Professor, AUTH • Eric Peirano, Project Manager of Grid+Storage, TECHNOFI
3	• All participants (plenary discussion) • Sophie Dourlens-Quaranta, Consultation coordinator for Grid+Storage, TECHNOFI

5.1.3 List of attendees

In total, the workshop was attended by 56 participants, listed in Table 13 below. [8]

Table 13 – Attendees in the fourth knowledge sharing workshop

NAME	COMPANY
Kostis Andreadis	HEDNO
Sofia Apostolopoulou	HEDNO
NIKOLAOS ARGYROS	INTRACOM Defense Electronics
Dionysia-Theodora Avgerinopoulou	European Institute of Law, Science and Technology
Anastasios Bakirtzis	Aristotle University of Thessaloniki
John Chadjivassiliadis	IENE (Institute of Energy for South-East Europe)
Markos Champakis	HEDNO
Dikeados Chris	IPTO
NICK CONSTANTOPOULOS	MINISTRY OF DEVELOPMENT
Spiros Corcokios	GREEN SA
Loukas Daoutis	HEDNO

[8] Only the attendees having agreed to have their names listed in the minutes of the workshops are included.

Aris Dimeas	NTUA
Telaki Dimitre	HEDNO
Sophie Dourlens Quaranta	TECHNOFI
Housos E	Upatras
Chalkia Eleni	CERTH
ALEXANDRA GEORGANTI NTALIAPE	independent
Rebekka Gkogkou	ICCS / NTUA
VIVI GOURIOTI	DESFA
Nikos Hatziargyriou	HEDNO
Vassilis Iliadis	AES Technologies
Mantzaris Ioannis	HDNO
Vasileios Ioannitis	Seabriz
Svisceva Irina	
Emmanouil Kakaras	Mitsubishi Hitachi Power Systems Europe GmbH
DIMITRIOS KANELLOPOULOS	PPC RENEWABLES S.A.
Kostas Kaousias	HEDNO
Evangelos Karfopoulos	Ntua
Vasiliki Katsiki	SYSTEMS SUNLIGHT S.A.
Stefanos Kokkinelis	HEDNO
Ioannis Koumparou	University of Cyprus
Pantelis Kourelis	HEDNO
DIONYSIOS KOUTSOUVELIS	INTRACOM DEFENSE ELECTRONICS
PANAGIOTIS KTENIDIS	TEI PIRAEUS - SEALAB
Ilias LAMPRINOS	Intracom Telecom
Panagiotis Maniatis	Greek Environmental & Energy Network
Marios Maniatopoulos	NTUA
Kelly Mavrogenou	ICCS/NTUA
Nikolaos Nikolopoulos	Centre for Research and Technology Hellas / Chemical Process and Energy Resources Institute
Christina Papadimitriou	ICCS
Stefanos Papaefthymiou	HEDNO
Grigoris Papagiannis	Aristotle University of Thessaloniki
DIMITRI PAPAKONSTANTINOU	HEDNO, HELLENIC ELECTRICITY DISTRIBUTION NETWORK OPERATOR S.A.
Apostolos Papakonstantinou	HEDNO
Stavros Papathanassiou	NTUA
Eric Peirano	TECHNOFI
Nikos Pomonis	SYSTEMS SUNLIGHT SA
VILLY REPOUSI	independent
Elias Spanos	ENET S.A.
Stathis Tselepis	CRES
Isidoros Vitellas	HEDNO
Alexander von Jagwitz	B.A.U.M. Consult GmbH
Spyros Voutetakis	Centre for Research and Technology Hellas (CERTH)
ΑΛΕΞΑΝΔΡΟΣ ΖΩΤΟΣ	INTRACOM DEFENSE ELECTRONICS (IDE)

5.2 Minutes of the debates

5.2.1 Session 1

- The economic feasibility of storage was discussed in relation with the price differential (spread) between peak and off-peak hours: at least 80€/MWh are needed in general. Still, island systems are a good business case for storage since generation prices are in general quite high (up to 300 €/MWh in the example mentioned), and capacity payments are implemented. To have more than 30% of RES on an island, dispatchable RES units such as Hybrid Power Stations (HPS) are needed.
- The issue of stand-alone storage vs. HPS was discussed: actually storage is viable only if there is a high level of RES curtailments. If RES and storage are owned by two different players, then storage would not be viable, as the simultaneous implementation of high RES capacity and storage facilities to handle their curtailments could not be easily coordinated in practice. A single investor for both RES and storage is needed.
- The issues of environmental constraints, permitting and communication to local people were discussed: they indeed occur for all projects. Still, the issue is not about the permits themselves but the complexity of the processes, which results in long durations and extra costs for investors.
- Comparison between storage in islands and on the mainland was debated: only if system services provided by storage are properly remunerated, storage can be viable on the mainland. So far in Greece, such services are not compensated sufficiently either for thermal units or for HPS. Also, the contribution of storage to security of supply should be valued.
- Centralised storage such as pumped hydro storage (PHS) is economically viable for the pan-European transmission grid under current market conditions (sufficient spread). For example, the Norwegian hydro provides services to the pan-European system (new HVDC links with Germany, the UK, Belgium, Denmark) are under construction. However, the issue of local opposition remains (both for the overhead lines and the water levels in impacted rivers and reservoirs).
- Residential storage (storage for auto-consumption in private homes or buildings) can be an option, but the beneficiaries should be identified. Still, benefits other than economic can be an incentive for households: for example in Germany, residential storage develops even if there is no business case; some people indeed like being self-sufficient in terms of energy supply.
- A paradox is raised: storage is needed to integrate more RES; but, under current market conditions, integrating more RES flattens market prices (spot price curve) and reduces the profitability of storage (for business models based upon the spread). Therefore innovations are needed in terms of market design and regulation to value the system services which can be brought by storage.
- It was reminded that energy storage is not the only flexibility means. Flexibility can come from the network (e.g. reinforcements such as cross-border interconnections and power electronics), generation (fast gas turbines for instance and variable speed machines for PHS), demand side management, and the connection with other energy networks.

5.2.2 Session 2

- Again conditions for energy storage viability are discussed. Islands combining high fossil fuel costs and high RES penetration are identified as the sole cases in which storage is viable under current regulations and market conditions. The issue of the sensitivity to fossil fuel price is raised: if the oil barrel remains cheap for a long period, it would be detrimental to the profitability of energy storage when installed in island networks where generation costs are high. Still, storage would remain necessary to compensate RES intermittency whatever the market prices are.
- The new HVDC link planned between Greece (mainland), Crete, Cyprus and Israel (EuroAsia interconnector) could change the business models for storage on the Greek islands.
- In general, one of the barriers to storage development is the double fee storage units have to pay, being considered both as producers and consumers.
- The issue of fully automated network management was raised, with the example of digitalised substations. Some consider that full automation is not realistic, for example for safety reasons. On the contrary, it was debated that multiple stakeholder schemes complicates the reliable operations of the power system. A possible way to combine an optimised level and automation and the involvement of several stakeholder was presented for distribution networks. This proposal remains to be tested and validated in real distribution networks.
- Cost of storage components are compared to the cost for the integration of storage into the grid. Cost reductions are expected during the upcoming years; still, incentives are needed to get to an early market.

5.3 Lessons learned from the workshop

These lessons and recommendations have been discussed and agreed upon during the final roundtable.

5.3.1 Impacts of the new knowledge presented by the six projects onto the GRID+STORAGE roadmap

The projects presented cover a large range of maturity levels for network operators, from TRL 4-5 for some applications to TRL 9 for some others

Storage as a flexibility option will impact the following TSO and DSO clusters in the roadmap:

- Operations,
- Market design.

5.3.2 Recommendations for future R&I activities and regional investments about grid and energy storage solutions

The following statements must be considered in the selection of the R&I activities for the future integrated roadmap:

- Hybrid stations, i.e. storage systems in a generation portfolio, are a suitable model for storage integration in systems where generation costs are very high and renewable penetration is saturated (typically islands).
- Multiservice business models for storage integration might be a solution provided that the system services brought by storage are fairly valued (regulations and market mechanisms).

- Power converter technologies bring new horizons in terms of control of the future smart grids, including storage integration. More R&I activities are needed to understand the complex system dynamics of power systems with large power electronics penetration.
- Permitting (duration and number of bodies) is still an issue for large-scale storage projects.
- Flexibility cannot be ensured only by storage technologies: R&I activities are needed for other flexibility means (interconnections and power electronics, flexible generation, demand management, connections with other energy networks, etc.).
- There is a need to design market incentives for the integration of small to large-scale storage (price signals, ownership, etc.) in an appropriate regulatory environment.
- Middleware layers (with multi-agent systems) are a possible alternative for the management of LV networks hosting large share of renewables (including prosumers and storage)

5.4 Projects willing to join the Knowledge Sharing Platform

A general invitation to join the GridInnovation-online community and submit articles was proposed to all the speakers and the workshop participants. Several were keen to submit articles. Some participants pointed out that the European Commission should make the platform more visible and suggest that each EC-funded project provides articles.

6 Workshop 5 (Spain, Portugal)

The fifth workshop was held in Madrid (Spain) on the 15th and 16th of February, 2016. The workshop agenda is available on the Grid+Storage website.

6.1 Projects and participants in the workshop

6.1.1 R&I projects presented

Eleven R&I projects were presented during the fifth workshop, as displayed in Table 14Table 8 – below.

Table 14 – Projects presented at the fifth knowledge sharing workshop

Project	Country	Purpose	Speaker	Link to presentation
The Almacena Li-ion battery project	Spain	Analyse challenges and features of electrochemical storage systems connected to the grid	Miguel Ordiales, Demand Side Management Project Manager, REE	Link
Flywheel applications on the Canary islands networks	Spain	Test flywheel technologies for frequency and voltage control applications	Cristina Gomez Simon, R&D and European Projects, REE	Link

The Life Factory Microgrid project	Spain	Test and demonstrate energy management strategies in microgrids	Raquel Garde, Energy Storage Area Manager, CENER	Link
The STORE project: Multiservice applications of storage for DSO applications	Spain	Integration of a Li-ion BESS in a substation to provide system services	Pablo Fontela, Project Manager R&D Unit, Endesa	Link
Lessons learned from the SIRVE project and perspective of the EV-OPTI Manager project	Spain	To develop and demonstrate a portfolio of solutions for charging electric vehicles, in which storage systems and distributed generation are integrated	José Francisco Sanz, Director of the Renewable Energy Integration (IER) Area, CIRCE	Link
National storage projects in Portugal	Portugal	To present the current status of energy storage projects in Portugal	José Oliveira Paulo, Assistant Director, ENERGYIN – Competitiveness and Technology Cluster for Energy and Ricardo Santos, Electrical Engineer, EDP Distribuição	Link
Multi-attribute Energy Storage Planning	Portugal	Transmission network planning studies integrating energy storage	Miguel Moreira da Silva, Head of Asset Management, REN	Link
Li-ion battery storage applications in Gas Natural Fenosa's distribution grid	Spain	To study the added-value brought by BESS in distribution networks in Spain	John Chamberlain, Project manager, Gas Natural Fenosa	Link
The InovGrid project	Portugal	Customer centric solutions to test demand response in the Évora city	Ricardo Santos, Electrical Engineer, EDP Distribuição	Link

Energy storage solutions in Spain	Spain	Presentation of FutureRed (Spanish Technology Platform for Electricity Networks): energy storage projects	Luis Manuel Santos, Head of R&D&I, EDP Spain	Link
The ALIA2 project	Spain	Li-ion batteries manufactured by CEGASA	Igor Cantero, R&D Manager, CEGASA	Link

6.1.2 Roundtables

The first three roundtables were mainly devoted to questions for the representatives of the presented projects. The fourth one aimed at summarizing the debates and analysing the impacts of the presented projects onto the R&I topics to be selected in the integrated roadmap.

Table 15 below shows the participants in each roundtable.

Table 15 – Participants in roundtables at the fifth knowledge sharing workshop

Roundtable nr.	Participants
1	• Cristina Gomez Simon, R&D and European Projects, REE • Raquel Garde, Energy Storage Area Manager, CENER • Eric Peirano, Project Manager of Grid+Storage, TECHNOFI
2	• Pablo Fontela, Project Manager R&D Unit, Endesa • José Francisco Sanz, Director of the Renewable Energy Integration (IER) Area, CIRCE • José Oliveira Paulo, Assistant Director, ENERGYIN – Competitiveness and Technology Cluster for Energy • Ricardo Santos, Electrical Engineer, EDP Distribuição • Eric Peirano, Project Manager of Grid+Storage, TECHNOFI
3	• Miguel Moreira da Silva, Head of Asset Management, REN • John Chamberlain, Project manager, Gas Natural Fenosa • Ricardo Santos, Electrical Engineer, EDP Distribuição • Luis Manuel Santos, Head of R&D&I, EDP Spain • Igor Cantero, R&D Manager, CEGASA • Eric Peirano, Project Manager of Grid+Storage, TECHNOFI
4	• All participants (plenary discussion) • Eric Peirano, Project Manager of Grid+Storage, TECHNOFI

6.1.3 List of attendees

In total, the workshop was attended by 84 participants, listed in Table 16below. [9]

Table 16 – Attendees in the fifth knowledge sharing workshop

NAME	COMPANY
Lola Alacreu	ETRA I+D

[9] Only the attendees having agreed to have their names listed in the minutes of the workshops are included.

Ricardo Albarracín	Boslan Ingeniería y Consultoría S.A.
Eva ALVAREZ	GAS NATURAL FENOSA
Rodrigo Alvarez	Iberdrola Renewables
Belen Amunategui	TECNICAS REUNIDAS
Monica Aragüés Peñalba	CITCEA - UPC
Paul Bartholomeus	Inspiralia
Isabel Blaak	WRD GmbH
Guillermo Bravo Mínguez	Indra
Borja Cañas	IBERDROLA
Maria Gabriela Cañete Cardona	CIRCE
Igor Cantero	CEGASA PORTABLE ENERGY
Jorge Cardenas Medina	General Electric
Alicia Carrasco	siemens
John Chamberlain	Gas Natural Fenosa
Javier Coca	gas natural fenosa
Irene Danti Lopez	University College Dublin
Rubén de Arriba Aparicio	ACS-COBRA
Ignacio Delgado	Instituto Tecnológico de la Energía
Jose Miguel Estebaranz Pelaez	Iberdrola Ingenieria
Pablo Fontela Martinez	ENEL
Pavel José Fueyo Rodríguez	Iberdrola Clientes S.A.U.
Miguel Garagorri	IBERDROLA
Raquel Garde	CENER
Jean Gardy Germain	GAS NATURAL FENOSA
Iva Maria Gianinoni	RSE
Cristina Gómez	REE
Pilar Gonzalez	Iberdrola
Alezeia González	Gas Natural Fenosa
Pilar González	CDTI
Roberto González Sainz-Maza	Iberdrola España
Juan Hernandez	Proinsener Energía
Daniel Hernández Maldonado	TECHNOFI
Ana Ibañez	Tecnicas Reunidas
Eduardo Jimenez	INDRA
Eduardo Lopez de Armentia	AEG Power Solutions Iberica
Marta Lopez González	Universidad Politecnica de Madrid
Jesus Lugaro	SAFT
Bart Mantels	VITO / EnergyVille
José L. Martinez-Ramos	UNIVERSITY OF SEVILLE
Marta Méndez Bonito	SIEMENS
David Menendez	General Electric
Aitor Milo	IKERLAN SCoop
Eduardo Navarro	Iberdrola Distibución Eléctrica
Jesus Nieto Martin	Cranfield University
Emilio Nicolás Obregón	Beter Energy
Francisco Ortiz de Obregon	IBERDROLA ENGINEERING & CONSTRUCTION
Ion Ortiz de Pinedo	CEGASA PORTABLE ENERGY
José Paulo	EnergyIN
Allan Schroeder Pedersen	Technical University of Denmaark
Eric Peirano	TECHNOFI
Javier Perez Sousa	ARTECHE

Sergio Platón Martínez	Iberdrola
Ignacio Porto Olivares	Unión Fenosa Distribución
Antonio Puerta Vicente	SIEMENS S.A.
Nadia Rego	Embassy of Canada
Maria Luisa Revilla	CDTI- Centre for the Development of Industrial Technology
Andrea Rinaldi	Kratzer Automation
Esther Romero Ramos	University of Sevilla
Javier Sacristan	UNION FENOSA DISTRIBUCION
Luis Manuel Saiz	INEGETEAM
Fernando Salazar	Gas Natural Fenosa
Natalie Samovich	Enercoutim
Javier Sanchez	SAFT
Samuel Sánchez	NORVENTO Energía Distribuida
Juan Sanciñena	Zabala Innovation Consulting
Ricardo Santos	EDP
Luis Santos	EDP
José Sanz	CIRCE
Manuel Serrano	ETRA I+D
Mario Silva	EFACEC
Nuno Silva	EFACEC
Anabel Soria	Instituto Tecnológico de la Energía
Nuno Taveira	Enercon
Jesus Varela Sanz	Iberdrola Distribucion Electrica
Maria Teresa Villén	CIRCE
Angel Yunta Huete	UNION FENOSA DISTRIBUCION (GRUPO GAS NATURAL FENOSA)
Miguel Moreira da Silva	REIV
Angel Rosso Mateo	NORVENTO Energía Distribuida
Luis Diez Maroto	NORVENTO Energía Distribuida
Luis Martin Blazquez	Iberdrola
Laura Fernandez Valero	NORVENTO Energía Distribuida
Henrik Dam	European Comission
Carolina Garcia	Inspiralia

6.2 Minutes of the debates

6.2.1 Session 1

Questions/discussions following the presentation of Miguel Ordiales, Demand Side Management Project Manager, REE

- Storage integration in transmission networks and more especially the added value for TSOs' activities were debated. The Almacena project has provided important information on the flexibility offered by the tested BESS (NEC Li-ion batteries providing power-frequency regulation, voltage regulation and load shifting for both active and reactive power) as well as the limits in terms of operation and the associated maintenance. General questions were raised about the regulatory framework for regulated operators such as TSOs (ownership of the asset and the associated remuneration scheme). Emphasis was put on the importance of the

ageing models since most available BESS of that size (rated power and energy) are prototypes.

Questions/discussions following the presentation of Cristina Gomez Simon, R&D and European Projects, REE

- A prototype flywheel was successfully tested (1.6 MW, 18 MWs) to provide mainly frequency and voltage control services as well as inertia. The size of the flywheel (including its technology) and the location were discussed: Cristina Gomez Simon explained that the specifications were supported by multiple-scenario simulations (10-12 different locations were studied).
- This pilot project on the Canary Islands is directly related to the Almacena project: REE is testing the system services that can be brought by different storage technologies (flywheels and batteries).

Questions/discussions following the presentation of Raquel Garde, Energy Storage Area Manager, CENER

- Infrastructure and system control costs of the Life Factory Microgrid project were discussed, pointing out that the BESS (flow battery from Jofemar) is the most significant part in the capital costs.
- Raquel Garde specified that the control system was very complicated to set up. In particular, the lack of harmonised ICT protocols and the need for a high communication speed to ensure the proper control of the microgrid were stressed.
- Energy efficiency of the micro grid, its optimization and the estimation of its performances were discussed: PE (power electronics) were identified as the key issue (i.e. convertors efficiency). Some possible solutions for improvement were mentioned: solid state switches based on superconductors to avoid crossover distortions.
- The integration/combination of several storage technologies was discussed: the lack of standard technologies is a major barrier for successful system integration.

6.2.2 Roundtable 1

Two main points were debated during the round table: the regulatory framework for storage assets when owned and operated by regulated players (TSOs and DSOs) as well as the growing importance of PE in the technical performances and costs of storage devices.

- Regulation and market issues for regulated players were debated: regulated players are testing storage solution so as to use them for system services. All demonstrations show that there is a strong added value for network operators when operating storage devices (system services). The lack of a clear regulatory framework in Spain was stressed. The EC pointed out that network operators are market makers and as such they should only be able to own and operate storage devices for specific system services without creating market distortions.

- The experts agreed to say that storage technologies must provide as many system services as possible so as to be profitable: PE were identified as the key technology to implement multi-service storage technologies. It was then stressed that the decrease in costs (and the efficiency and reliability) of PEs would become a major R&D issue since representing a growing part in the overall costs of storage system technologies (and in particular BESS where the costs of the cells are expected to decrease).

6.2.3 Session 2

Questions/discussions following the presentation of Pablo Fontela, Project Manager R&D Unit, Endesa

- Endesa (ENEL) presented its storage integration test activities (flywheel, ultra-capacitor and BESS) in the MV network of Gran Canaria. As in the demos presented by REE, storage devices can provide valuable system services for distribution network operators, especially in weak grids such as the ones encountered in islands. In such a case, the location of the storage device is a key factor.

- Discussions were focussed on the results of the BESS tests and especially the measured overall efficiency (roughly 75%, similar to PHS). There are a lot of auxiliaries (cooling for instance) in such systems which consume energy: these consumptions should increase with the need for more powerful and flexible PE interfaces.

Questions/discussions following the presentation of José Francisco Sanz, Director of the Renewable Energy Integration (IER) Area, CIRCE

- CIRCE presented the lessons learned from the SIRVE project regarding charging stations for electric vehicles (EVs). A possible way to mitigate the impact of fast charging stations on the grid is to improve the PE interfaces so as to better control the generated load (PEs can also provide active power, reactive power compensation and harmonic filtering). Another way is to associate storage devices so as to accumulate energy during periods of low use of the chargers.

- An EVSCSP (EV Charging Service Provider[10]) business model was successfully tested on a demo site. The coming EV-OPTI MANAGER project was then presented where the EV Charging Service provider using storage systems not only provides EV charging services for the EVs drivers but also ancillary services to the network operators. An aggregator model will also be tested, i.e. the EV Service Coordinator which groups several EVCSP and end-use consumers.

Questions/discussions following the presentation of José Oliveira Paulo, Assistant Director, ENERGYIN – Competitiveness and Technology Cluster for Energy and Ricardo Santos, Electrical Engineer, EDP Distribuição.

- The implementation of diversified energy projects in the whole Iberian Peninsula was discussed (mainly PHS and BESS). The speakers stressed that the Spanish and Portuguese governments should improve regulations and tariff issues, for instance for self-consumption. The need of profitable business models for storage and a stronger cooperation between Iberian operators was debated.

6.2.4 Roundtable 2

Two main points were discussed during this second round table: the need for integrated design and standardised protocols, especially for BESS systems with a lot of PE, as well as the need for extended field experiments.

- Integrated design of storage devices (batteries and power electronics) and standardization of the protocols were discussed: common procedures between battery suppliers should be imposed to decrease costs and reduce efforts for control

[10] Players being consumers, and which are entitled to the resale of electricity to recharge energy services and for electrical energy storage for better management of the Electrical System.

in operation. Integrated design should help to reduce investment costs and ensure multiservice storage platforms.

- There is a need for more pilot projects to improve storage integration and generate ideas for profitable business models: market players still need field experiments to really understand what they can implement in terms of system services (discussions on the real profitability of the business cases presented by AES, cf. first workshop in Lille, and by Tesla were debated). The need for powerful simulations tools (and databases, for instance typical energy storage profiles) was stressed: these tools could help to determine the most profitable storage applications (ageing models for instance).

6.2.5 Session 3

Questions/discussions following the presentation of Miguel Moreira da Silva, Head of Asset Management, REN

- All participants agreed to recommend the allocation of further research funds for the planning activities of network operators integrating energy storage. In the IEEE case study presented by REN, the developed algorithm gave valuable solutions that minimise the total requirement of energy storage, while reducing the final investment cost for the network operators. As a consequence, energy storage, when integrated to planning activities brings alternatives to network refurbishment (or new lines).

Questions/discussions following the presentation of John Chamberlain, Project manager, Gas Natural Fenosa

- The network operators need more time to identify and analyse case studies where the use of a storage system (BESS) could potentially resolve future issues/problems in the most economical way, according to the current regulations.
- For BESS, PE development and communication protocol issues were mentioned. Integration of design is a key issue to decrease costs both for investment and O&M costs. Standardization of the communication protocols and a stable regulatory environment were also identified as key issues for storage integration.

Questions/discussions following the presentation of Ricardo Santos, Electrical Engineer, EDP Distribuição

- The audience commented the impressive results of the InovGrid project regarding end-user involvement in the city of Evora, Portugal. A permanent reduction of electricity consumption (around 4%) all along the project duration (4 years) was achieved. Ricardo Santos explained how social media and good communication strategies were key elements to maintain end users' participation and motivation: households had small savings in their electricity bills. Questions about the demand-side management and control systems of the project were put forward: PC and mobile applications were used to control the EDP BOX smart meter. The cyber security measures of the project were discussed. The collaboration and ancillary services provided to Evora's Municipality generated interesting BC (i.e. public lightning network management.

Questions/discussions following the presentation of Luis Manuel Santos, Head of R&D&I, EDP Spain

- Luis Manuel Santos presented the FutuRed platform which is the Spanish Technology Platform for Electricity Networks, and explained the conclusions of the different working groups. The conclusions of the Regulatory working group were

discussed at length, i.e. the lack of a regulatory framework for immature storage technologies and the need to extend the permission to install electricity storage in PHS and thermal solar generation facilities to all generation technologies.

- A presentation of the competitiveness of each storage technology was given: a study on the number of patents issued each year by type of companies and countries showed that the BESS industry is the hands of three countries: Japan, the US and to some extent South-Korea.

Questions/discussions following the presentation of Igor Cantero, R&D Manager, CEGASA

- Questions about the different batteries chemistry strategy elaborated by Cegasa were asked. The batteries diversification aims at broadening the clientele offering solutions for multiple applications (transmission and distribution activities) and having more profitable business models and better market impact.

6.2.6 Roundtable 3

- It was said that the development of more storage projects with pilots and demos are needed in order to improve the knowledge of storage applications and services. Asset management was discussed as well: i.e. Javier Sanchez Collada and Jesus Lugaro Duelo from SAFT explained that batteries' OPEX integrated in the grid (power electronics included) would represent 2 to 4% of the CAPEX according to SAFT's experience.

- It was commented that European nations should use a wide range of batteries' technologies like other countries (Li-ion dependence): Japan and US for instance. Moreover, Europe should ensure the raw materials provision in order to avoid dependence on supplier countries. The attendees debated about batteries' recycling and 2nd life-batteries integration to the grid. Batteries' ageing and its modelling were discussed. SAFT members explained that the battery's technology (electrochemistry) can be adapted depending on the users' different profiles. The users' specifications and profiles would allow to provide better OPEX estimations and improve batteries lifespan simulations. The lack of different standard user's profiles to be used in performance tests in order to have certifications and harmonised results were discussed.

- It was highlighted that grid planning and development should be conceived for a better battery integration. A better support of operators with analytic tools in order to help storage integration was asked. Batteries and PE suppliers should collaborate in order to facilitate their grid integration and compatibility.

6.3 Lessons learned from the workshop

These lessons and recommendations have been discussed and agreed upon during the final roundtable.

6.3.1 Impacts of the new knowledge presented by the six projects onto the GRID+STORAGE roadmap

The projects presented cover a large range of maturity levels for network operators, from TRL 4-5 for some applications to TRL 9 for some others

Storage as a flexibility option will impact the following TSO and DSO clusters in the roadmap:

- Operations,

- Asset management,
- Planning,
- Market design

6.3.2 Recommendations for future R&I activities and regional investments about grid and energy storage solutions

The following statements must be considered in the selection of the R&I activities for the future integrated roadmap:

- BESS: there is a need for integrated design of the systems, i.e. a joint design between battery manufacturers and PE (power electronics) providers, in order to optimise costs with the maximum coverage in terms of functionalities.
- BESS: there is a need of simulation tools to better appraise the cycling profiles associated to the envisaged applications and business models. This will, in turn, allow to estimate accurately the lifespan of the system and profitability.
- BESS: need for duty cycle standards so as to give undisputed performance certifications (link with IEC activities).
- Standardised communication protocols between BESS and PE.
- Power electronics (PE) bring new horizons in terms of control of the future smart grids, including storage integration. More R&I activities are needed to understand the complex system dynamics of power systems with large PE penetration. A distinction between distributions and transmission networks should be made.
- There is still a need for focused demonstration projects (with a set of specific applications) so as to understand how the BESS can be used in the power system. Collaborations between the industry (manufacturers) and the end users such as network operators should be encouraged.
- Multiservice business models for storage integration might be a solution provided that the system services brought by storage are fairly valued (regulations and market mechanisms).
- Storage should be integrated in a portfolio of activities so as to maximise its value. The storage agent model is only viable in case of large spread.
- Regulated players will integrate storage solutions. However, as market makers, the scope of the business models might be limited (better operate the network).
- For regulated players, such as network operators, the location of storage is key when performing planning studies.
- Flexibility cannot be ensured only by storage technologies: R&I activities are needed to compare storage with other flexibility means (interconnections, demand management, connections with other energy networks, etc.). CBA tools should include not only economics but also environmental and social aspects (LCA).
- There is a wide portfolio of storage technologies which fulfil different functionalities. Hybrid systems could help to cover wider ranges of functionalities.

6.4 Projects willing to join the Knowledge Sharing Platform

A general invitation to join the GridInnovation-online community and submit their respective projects was proposed to all the speakers and the workshop participants.

7 Workshop 6 (Austria, Czech Republic, Hungary, Slovakia)

The sixth workshop was held in Vienna (Austria) on the 24th of February, 2016. The workshop agenda is available on the Grid+Storage website.

7.1 Projects and participants in the workshop

7.1.1 R&I projects presented

Four R&I projects were presented during the sixth workshop, as displayed in Table 17Table 8 – below.

Table 17 – Projects presented at the sixth knowledge sharing workshop

Project	Country	Purpose	Speaker	Link to presentation
The LEAFS project	Austria	Relief of the local distribution grid through coordinated operation; reduced costs for additional distributed generation; enable market participation for various components; new service possibilities for DSOs and other market participants	*Johannes Kathan, R&D engineer, Austrian Institute of Technology*	Link
The EStore-M project: Electricity Storage Management	Austria	Development of an adaptive scheduling controller for the use of renewable energy, storage devices and certain electricity loads which incorporates weather- and load-forecasts and robust optimisation; development of specific meteorological energy forecast methods; analysis of energy efficiency of energy systems over the whole lifetime and development of failure detection algorithms.	*Harald Kirchsteiger, Researcher, Austria Solar Innovation Center*	Link
The SORGLOS project	Austria	Use smart grid technology to create blackout resistant feeders (low voltage) or grid sections (medium voltage). Assuming that decentralised renewable electricity generation, smart meters and energy storage are installed, what additional devices or functions of installed devices are needed to allow stable island operation?	*Michael Chochole, Project Assistant, TU Vienna*	Link

The Callia project - Open Inter-DSO electricity markets for RES integration	Austria	Development of technologies and concepts to limit RES curtailment by local matching of supply/demand including RES at DSO level, and enhancing balancing between local DSO and global TSO	*Ferdinand von Tuellenburg, Research & Development, Salzburg Research*	Link

7.1.2 Roundtables

The first two roundtables were mainly devoted to questions for the representatives of the presented projects. The third one aimed at summarizing the debates and analysing the impacts of the presented projects onto the R&I topics to be selected in the integrated roadmap. Table 18 below shows the participants in each roundtable.

Table 18 – Participants in roundtables at the sixth knowledge sharing workshop

Roundtable nr.	Participants
1	• Johannes Kathan, R&D engineer, Austrian Institute of Technology • Harald Kirchsteiger, Researcher, Austria Solar Innovation Center • Sophie Dourlens-Quaranta, Grid+Storage Stakeholder Consultation Coordinator, TECHNOFI
2	• Michael Chochole, Project Assistant, TU Vienna • Ferdinand von Tuellenburg, Research & Development, Salzburg Research • Sophie Dourlens-Quaranta, Grid+Storage Stakeholder Consultation Coordinator, TECHNOFI
3	• All participants (plenary discussion) • Sophie Dourlens-Quaranta, Grid+Storage Stakeholder Consultation Coordinator, TECHNOFI

7.1.3 List of attendees

In total, the workshop was attended by 16 participants, listed in Table 19 below. [11]

Table 19 – Attendees in the sixth knowledge sharing workshop

NAME	COMPANY
Michael Chochole	TU Wien
Sophie Dourlens-Quaranta	TECHNOFI
Daniel Hernandez Maldonado	TECHNOFI
Michael Hübner	BMVIT
Albana Ilo	TU Wien
Václav Janoušek	ČEZ Distribuce
Ludwig Karg	B.A.U.M. Consult

[11] Only the attendees having agreed to have their names listed in the minutes of the workshops are included.

Johannes Kathan	Austrian Institute of Technology
Kris Kessels	VITO
Harald Kirchsteiger	Austria Solar Innovation Center
Klaus Kubeczko	Austrian Institute of Technology
Thomas Nacht	4ward Energy Research GmbH
Simon-Pierre Rheaume	Botschaft von Kanada
Allan Schroeder Pedersen	Technical University of Denmark
Wolfgang Vitovec	Netz Niederösterreich GmbH
Ferdinand von Tüllenburg	Salzburg Research Forschungsgesellschaft mbH

7.2 Minutes of the debates

7.2.1 Roundtable 1

Several points were discussed during this first roundtable:

- Different aspects concerning the households demonstrations of the LEAFS project were discussed: the strategies chosen for integrating and motivating the different households in order to make them participate within the LEAFS project were tackled. The use of different kind of incentives was debated. Johannes Kathan added that the project has already integrated some hundreds of participants and the households' recruiting phase is still ongoing. The public highlighted the difficulty of obtaining people's participation in this kind of projects and the need of optimal communication strategies: the LEAFS project was compared with the Nice Grid demonstration (Grid4EU project) regarding these aspects.

- Questions were raised concerning Cybersecurity and ICT integration for pilot projects: the collected data ownership and the different privacy problems related to these subjects were debated.

- Regarding the EStore-M project, questions were raised about the design of variable tariffs and the minimum spread needed to ensure sufficient revenues for the battery system.

- Charging/discharging batteries' regulation issues were discussed. The storage decentralization and its implementation at LV were debated. The audience agreed upon the need of a common and coherent architecture planning between HV, MV and LV grids for storage integration. VPP and Microgrids implementation were tackled as well.

7.2.2 Roundtable 2

Two main points were discussed during this second round table:

- The contribution of different storage sources during island mode of operation for the SORGLOS project was asked. The attendees debated about collective and cooperative solutions, their economic viability and taxation in order to face different energetic issues.

- Concerning the CALLIAS project, the creation of new business models for the system were commented. Once again, the architectural nice approach of the overall system was evoked by the participants.

7.3 Lessons learned from the workshop

These lessons and recommendations have been discussed and agreed upon during the final roundtable.

7.3.1 Impacts of the new knowledge presented by the six projects onto the GRID+STORAGE roadmap

The projects presented cover a large range of maturity levels for network operators, from TRL 2-3 for some applications to TRL 7 for some others.

Storage as a flexibility option will impact the following DSO (TSO) clusters in the roadmap:

- Operations,
- Market Design,
- Integration of DER and new uses,
- Integration of smart consumers.

7.3.2 Recommendations for future R&I activities and regional investments about grid and energy storage solutions

The following statements must be considered in the selection of the R&I activities for the future integrated roadmap:

- Need to share good practices in motivating, recruiting and incentivizing end-consumers.
- Optimizing individual benefits at consumer level should consider the effects on the physical power grid (at TSO and DSO levels) and on the macroeconomic optimum.
    - How to assess the benefits of a given solution at socio-technical system level?
    - How to increase the benefits at socio-techniical system level?
- The need for a market and regulatory framework for installing storage devices (for instance batteries) at any level (for instance at district level) to optimise macro-economic benefits
    - It is necessary to create a role of storage operator?
- Data ownership, privacy and integrity issues to be further investigated (for instance cybersecurity for consumer data in cloud, in particular for industrial consumers).
- Legal/regulatory aspects: DSO have black start capabilities and could participate in building up the grid after a blackout (TSO responsibility): this service is currently not compensated.
- Current regulatory framework missing for inter-district trading.
- Exploit big trend towards collective/cooperative solutions (platform or sharing economy).
- Interoperability and standardised interfaces.
- Explore cross-energy carriers' synergies (for instance P2H, P2G).

7.4 Projects willing to join the Knowledge Sharing Platform

A general invitation to join the GridInnovation-online community and submit their respective projects was proposed to all the speakers and the workshop participants.

8 Workshop 7 (Croatia, Italy, Malta, Slovenia, Switzerland)

The seventh workshop was held in Rome (Italy) on the 29th of February and 1st of March, 2016. The workshop agenda is available on the Grid+Storage website.

8.1 Projects and participants in the workshop

8.1.1 R&I projects presented

Seven R&I projects were presented during the seventh workshop, as displayed in Table 20 below.

Table 20 – Projects presented at the seventh knowledge sharing workshop

Project	Country	Purpose	Speaker	Link to presentation
The SINCRO.GRID project	Slovenia, Croatia	To deploy compensation devices to support RES integration, improve system operation security and grid efficiency, increase technical transmission capabilities and improve ancillary service technologies and markets.	Uroš Salobir, General Coordinator for System Development, ELES	Link
Experiences and initial results from Terna's Energy Storage Projects	Italy	Energy storage solutions to optimise integration of RES and increase flexibility of national grid (i.e. smarter grid)	Anna Carolina Tortora, Head of Innovation and development, TERNA	Link
The SIREN project	Croatia	Investigate operating procedures for running the Croatian power system with high level of uncertain (wind generation); derive investment strategies that will enable high penetration of wind energy into the Croatian power system; determine requirements for connection of new wind power plants to the Croatian transmission network; analyze the needs for storage in Croatian transmission network; define regulations for utilization of such storage technologies depending on the ownership (HOPS vs. third parties)	Hrvoje Pandžić, Assistant Professor, University of Zagreb	Link

The ACEA Distribuzione smart-grid pilot project	Italy	From smart and resilient grid to smart and resilient city: a new paradigm, the Internet of Energy	Stefano Liotta, Responsabile Ingegneria, Pianificazione e Sviluppo Smart Grid, ACEA	Link
The Role of Energy Storage for TSOs	Switzerland	Analysis of trade-off between improved transmission technologies on the one hand, and use of energy storage or control of load on the other hand	Jonas Mühlethaler, Specialist Technology Development, Swissgrid	Link
The 'Smart Polygeneration Microgrid of the Genoa University'	Italy	Presentation of a 3-phase low voltage (400V line-to-line) "intelligent" distribution system coupled with a thermal network at the Savona University Campus	Stefano Bracco, Department of Naval, Electrical, Electronic and Telecommunication Engineering, University of Genoa	Link
A Smart battery assisted by a CHP to meet the power and energy demand in a PV powered house	Malta	Presentation of a "Smart Home" energy system (PV, CHP, storage) as an energy efficient solution to provide electricity and heat at domestic level. It can also be a solution to the problem of excessive high voltage in areas with high PV concentration	Neville Azzopardi, Senior electrical engineer, Albertax Technologies Ltd	Link

8.1.2 Roundtables

The first three roundtables were mainly devoted to questions for the representatives of the presented projects. The fourth one aimed at summarizing the debates and analysing the impacts of the presented projects onto the R&I topics to be selected in the integrated roadmap. Table 21 below shows the participants in each roundtable.

Table 21 – Participants in roundtables at the seventh knowledge sharing workshop

Roundtable nr.	Participants
1	• Uroš Salobir, General Coordinator for System Development, ELES • Anna Carolina Tortora, Head of Innovation and development, TERNA • Hrvoje Pandžić, Assistant Professor, University of Zagreb • Eric Peirano, Project Manager of Grid+Storage, TECHNOFI

2	• Stefano Liotta, Responsabile Ingegneria, Pianificazione e Sviluppo Smart Grid, ACEA • Jonas Mühlethaler, Specialist Technology Development, Swissgrid • Eric Peirano, Project Manager of Grid+Storage, TECHNOFI
3	• Stefano Bracco, Department of Naval, Electrical, Electronic and Telecommunication Engineering, University of Genoa • Neville Azzopardi, Senior electrical engineer, Albertax Technologies Ltd • Luigi Mazzocchi, director RSE generation and materials department – in charge of storage in RSE
4	• Norela Constantinescu, ENTSO-E • Antonio Iliceto, Terna (representing ENTSO-E) • Gareth Bissell, Network Development at Enel Distribuzione (representing EDSO) • Allan Schroeder Pedersen, Technical University of Denmaark (representing EASE) • Luigi Mazzocchi, director RSE generation and materials department – in charge of storage in RSE • Sophie Dourlens-Quaranta, Grid+Storage Stakeholder Consultation Coordinator, TECHNOFI

8.1.3 List of attendees

In total, the workshop was attended by 28 participants, listed in Table 22 below.

Table 22 – Attendees in the seventh knowledge sharing workshop

NAME	COMPANY
Neville Azzopardi	Abertax Technologies Ltd
Massimo Bertoncini	Engineering Ingegneria
Gareth Bissell	Enel
Stefano Bracco	University of Genoa
Norela Constantinescu	ENTSO-E
Tatjana Corlija Milivojevic	Hrvatska Elektroprivreda d.d.
Sophie Dourlens-Quaranta	TECHNOFI
Corallie Durand	C.V.A. S.p.A.
Iva Maria Gianinoni	RSE - Ricerca sul Sistema Energetico
Antonio Iliceto	Terna
Kristina Jurkovic	Faculty of Electrical Engineering and Computing
Kris Kessels	VITO
Mate Lasić	HOPS
Stefano Liotta	ACEA DISTRIBUZIONE
Luigi Mazzocchi	RSE
Jonas Mühlethaler	Swissgrid Ltd
Andrea Nicci	Terna
Hrvoje Pandzic	Faculty of Electrical Engineering and Computing University of Zagreb
Allan Schroeder Pedersen	Technical University of Denmark
Eric Peirano	TECHNOFI
Ervin Planinc	ELES
Tomislav Plavsic	HOPS - Croatian Transmission System Operator

Maja Rajčić	Environmental Protection and Energy Efficiency Fund
Francesca ROGAI	ACEA
Uroš Salobir	ELES
Patrizia Santoro	University of Salerno
Ivona Štritof	Hrvatska Elektroprivreda d.d.
Anna Carolina Tortora	Terna Spa

8.2 Minutes of the debates

8.2.1 Roundtable 1

Several points were discussed during this first roundtable:

- Questions were raised about the generation mix in Croatia and Slovenia. Actually about one third comes from hydro run of river (RoR) and another third from nuclear. Consequently only one third of the capacities are able to provide flexibility. Cross-border interconnection are also heavily congested.
- Storage technologies able to provide primary reserve (fast response, up and down) were discussed. According to TERNA, batteries could be suited to provide such services: however, preliminary cycling tests seem to show that the specific cycle profile is going to significantly reduce the lifespan foreseen by the manufacturers.
- Regarding storage devices installed by the TSOs, buying services rather than buying devices was discussed. It was also highlighted regarding cost-benefit analyses, that TSOs have to find "system cases" rather than "business cases": they have provide an added-value for the whole electric system (social welfare).
- It was also suggested that TSO-owned storage devices may be allocated to market players through Financial Transmission Rights (FTRs).
- The CAPEX of integrated BESS (power electronics, batteries, battery management systems (BMS), and inverters) was discussed. Regarding BMS and power electronics, a significant increase in the volume of sales should lead to a decrease in prices.
- In principle, flexibility services should be provided by the market, and storage devices owned by TSOs should be used only under certain circumstances (time-limited and service-limited). Still, this debate should not be closed: the market may not always be able to provide such services and the TSOs should be allowed to provide flexibility solutions themselves.

8.2.2 Roundtable 2

Two main points were discussed during this second round table:

- DSOs will have an increasing dispatching role: as a consequence, they need to be able to closely monitor the low voltage (LV) network. LV automation is increasingly needed to better balance local load and production, in connection with other energy networks which need electricity for their day-to-day operations (gas, water, waste). The right level of automation at LV level was discussed: it cannot be at the same level than in medium voltage (MV) networks (complexity).
- The issue of storage ownership was again discussed. DSOs owning storage should be considered, as well as TSOs, in particular in markets with low level of competition. Some participants consider that storage could foster the development of competition, with foreign companies investing; others consider that TSOs or DSOs cannot always wait for the development of a market.

8.2.3 Roundtable 3

Several points were discussed during the third round table:

- Main objectives of the projects: Renewable exploitation, energy efficiency increase, CO_2 emission reduction, PV hosting capacity, flexibility at daily and seasonal levels.
- Energy efficiency is mandatory only for fossil sources, for RES it is a cost and a market issue, not an environmental issue.
- Use of storage should be enlarged including uses in transport and heating energy uses, power to gas for example.
- Customer benefits have been demonstrated: Load shift, Peak shaving, self-consumption. Potential advantages for the Distribution Grid: still to be demonstrated.
- Regarding microgrids, rules at EU level for exchanging energy with prosumers and DSOs are needed. A microgrid may not be compliant with existing national or European legislation.
- The dynamic properties of district heating systems were discussed. Monitoring buildings from a thermal point of view appears necessary to understand the real dynamics of the coupled system (the heat network and the buildings).

8.3 Lessons learned from the workshop

These lessons and recommendations have been discussed and agreed upon during the final roundtable.

8.3.1 Impacts of the new knowledge presented by the six projects onto the GRID+STORAGE roadmap

The projects presented cover a large range of maturity levels for network operators, from TRL 3-4 for some applications to TRL 9 for some others.

Storage as a flexibility option will impact the following TSO and DSO clusters in the roadmap:

- Operations,
- Market design,
- Planning,
- Integration of DER,
- Integration of smart consumers

8.3.2 Recommendations for future R&I activities and regional investments about grid and energy storage solutions

The following statements must be considered in the selection of the R&I activities for the future integrated roadmap:

- Storage is one flexibility means among other solutions: power electronics based devices (FACTS), cross-border coordinated operations, demand response, generation plants flexibility/predictability, etc.
- There is a need for analysing and comparing storage technologies performances (especially electrochemical technologies) to appraise the lifespan and performances depending upon the targeted services (and associated cycling profiles). Possible services provided by storage to TSOs/DSOs should be specified and characterised (energy intensive vs power intensive).
- R&I activities are needed to integrate storage devices into the system (standardised interfaces and lower cost of Balance of System).
- A regulatory framework and business models for storage (including the ownership issue by the regulated players) should be proposed.
- Opportunity to have storage connected to generation units (for instance on-board offshore wind farms to provide system services such as inertia) should be further investigated.

- From the TSOs point of view, storage may be used for:
  - congestion management purposes,
  - deferring investment in the grid,
  - providing inertia,
  - improving frequency control.
- DSOs will increasingly perform network management tasks and more automation in MV networks is needed.
- DSOs should use a phased approach to improve monitoring (using AMI if available) and possibly leading to some level of automation of LV networks
- The regulatory framework concerning distribution grids remains to be defined, especially the interactions between the different stakeholders (DSO, aggregators, retailers and other market players).
- R&I activities are needed in terms of communication architecture, i.e. standardised protocol between storage devices, inverters, etc.
- Regarding microgrids, optimal architectures should be studied, CBA should be carried out and legislation may have to evolve.
- How to organise self-consumption to control its effects on the system?
- Energy management systems should take into account all stochastic aspects (renewable production linked to weather forecasts in addition to other uncertainties such as load, failure of network components, etc.).
- New innovative control strategies to better control PV and storage systems so as to locally optimise balancing.
- At building level, thermal load must be monitored so as to better understand the dynamics of the coupled energy systems (electricity-heat-buildings).
- In planning studies, a proper energy mix has to be considered so as to cope with the seasonal effects as well as day/night cycles.
- Storage technologies other than batteries must be further investigated to cope with electrification of transportation, heating and cooling (power to gas, power to heat).

8.4 Projects willing to join the Knowledge Sharing Platform

A general invitation to join the GridInnovation-online community and submit their respective projects was proposed to all the speakers and the workshop participants.

9 Workshop 8 (Germany, Poland)

The eighth workshop was held in Munich (Germany) on the 9th and 10th of March, 2016. The workshop agenda is available on the Grid+Storage website.

9.1 Projects and participants in the workshop

9.1.1 R&I projects presented

Ten R&I projects were presented during the eighth workshop, as displayed in

Table 23 below.

Table 23 – Projects presented at the eighth knowledge sharing workshop

Project	Country	Purpose	Speaker	Link to presentation
The WEMAG 5 MW battery plant	Germany	The system's 5 MW power aims at helping to keep the transmission grid stable and integrate wind and solar power into the existing grid. It will provide frequency response and enable local black start of the grid.	*Wolfram Krause, Younicos*	Link
The M5BAT project	Germany	Construction of a pilot plant with various batteries' technologies targeting three main objectives: 1. Real operation on the market in various applications, 2. Evaluation of technical and economic findings and drawing up of operation and design recommendations 3. Development of various components of battery storage systems.	*Dr.-Ing. Christian Folke, Uniper*	Link
The Mega Watt battery on the PV Park Neuhardenberg	Germany	Development and test of business oriented storage control strategies on the largest PV plant in Europe: development of optimal operational strategies for energy storages by considering technical and economic criteria in different scenarios and different fields.	*Dr. –Ing. Pio Alessandro Lombardi, Fraunhofer Institute for Factory Operation and Automation IFF, Magdeburg*	Link
"Stadt als Speicher": using all built entities as storage potentials	Germany	This project aims at providing flexibility by making urban areas smarter: design of a Virtual Energy Storage System by pooling of various flexibility options. The project is assessed under real-life conditions, evaluates different coordination and communication strategies, and develops new business models for municipal utility companies and mechanisms for the avoidance of grid congestions (and grid expansions).	*Stefan Kippelt, Technische Universität Dortmund*	Link

The Flexible Energie Netze	Germany	The FEN Centre focuses at decentralized renewable generation, flexible grids and their modernization (hybridisation) and expansion: several projects were presented concerning DC technologies at HV, MV, LV and household levels.	*Prof. Monti Antonello, E.ON Research Center, RWTH Aachen*	Link
Effective Energy Storage System for photovoltaic RES and SMART GRID applications – ESME	Poland	Development of an Effective Energy Storage System with an innovative topology and control/management systems which aims at providing high power quality and cost savings (by proper energy management), uninterruptable power supply and to be operated in Smart Grids.	*Krzysztof Czernek, S.A.M. Polska Sp. z o.o.*	Link
The ADELE project	Germany	The project aims at developing a new adiabatic compressed-air energy system (A-CAES) power station (which can be also partially adiabatic with combustion and electrical auxiliary heating) up to bidding maturity for a first demonstration plant: cost optimization and use cases in the distribution grid by developing down-scalable concepts.	*Dr. –Ing. Pio Alessandro Lombardi, Fraunhofer Institute for Factory Operation and Automation IFF, Magdeburg*	Link
Energy storage operation in virtual power plants and future grids: Smart Region Pellworm and the DeCAS project	Germany	Development and demonstration of a blueprint for grid regions with storage systems, load flexibilities and renewables: Simulation and analysis of business models and operation strategies for a hybrid storage system operated together with renewables (VPP), installation of different batteries' technologies, electric storage heaters, smart metering equipment and EMS at different voltage and households' levels.	*Simon Koopmann, Team Leader Distributed Energy Systems, RWTH Aachen University*	Link

Verteilnetz2020, a practical approach to local grids	Germany	Increasing feed-in capacity and improving power quality in LV distribution grids: development of novel electrical equipment regarding voltage control and compensation of harmonics and integration of the new electrical equipment into automatic superordinated control *via* broadband-powerline (BPL).	*Markus Meyer, TU München*	Link
Power-to-X - results from various projects on cross-sectoral energy storage and network coupling	Germany	Presentation of the whole picture of the energetic transition: relevance of coupling the electricity and gas grids with power-to-X technologies, the gas grid as a large scale storage and fuel supply for the transport sector. Business cases integrating an energy multiservice approach: generation, consumption, storage, transportation, etc.	*Prof. Michael Sterner, Research Center for Energy Networks and Energy Storage, OTH Regensburg University AS*	Link

9.1.2 Roundtables

The first three roundtables were mainly devoted to questions for the representatives of the presented projects. The fourth one aimed at summarizing the debates and analysing the impacts of the presented projects onto the R&I topics to be selected in the integrated roadmap. Table 24 below shows the participants in each roundtable.

Table 24 – Participants in roundtables at the eighth knowledge sharing workshop

Roundtable nr.	Participants
1	• Wolfram Krause, Younicos • Dr.-Ing. Christian Folke, Uniper • Dr. –Ing. Pio Alessandro Lombardi, Fraunhofer Institute for Factory Operation and Automation IFF, Magdeburg • Eric Peirano, Project Manager of Grid+Storage, TECHNOFI
2	• Stefan Kippelt, Technische Universität Dortmund • Prof. Monti Antonello, E.ON Research Center, RWTH Aachen • Krzysztof Czernek, S.A.M. Polska Sp. z o.o. • Dr. –Ing. Pio Alessandro Lombardi, Fraunhofer Institute for Factory Operation and Automation IFF, Magdeburg • Eric Peirano, Project Manager of Grid+Storage, TECHNOFI
3	• Simon Koopmann, Team Leader Distributed Energy Systems, RWTH Aachen University • Markus Meyer, TU München • Prof. Michael Sterner, Research Center for Energy Networks and Energy Storage, OTH Regensburg University AS • Eric Peirano, Project Manager of Grid+Storage, TECHNOFI

4	• All participants (plenary discussion) • Eric Peirano, Project Manager of Grid+Storage, TECHNOFI

9.1.3 List of attendees

In total, the workshop was attended by 33 participants, listed in Table 25 below. [12]

Table 25 – Attendees in the eighth knowledge sharing workshop

NAME	COMPANY
Alexander von Jagwitz	B.A.U.M. Consult
Allan Schroeder Pedersen	Technical University of Denmaark
Andreas Zeiselmair	Forschungsstelle für Energiewirtschaft e.V.
Bart Mantels	VITO / EnergyVille
Blanda Prousch	RWE Deutschland AG
Christian Folke	Uniper Energy Storage
Daniel Hernandez Maldonado	TECHNOFI
Daniel Iglhaut	TÜV Rheinland Consulting GmbH
Eric Peirano	TECHNOFI
Grzegorz Dziechciaruk	S.A.M. Polska Sp. z o.o.
Helena Geissler	B.A.U.M. Consult
Janina Schneiker	B.A.U.M. Consult GmbH
Kedar Kolharkar	TenneT TSO GmbH
Krzysztof Czernek	S.A.M. Polska Sp. z o.o.
Łukasz Torbus	Tauron Polska Energia
Markus Meyer	Technical University of Munich (TUM)
Matthias Seel	Netze BW GmbH
Michael C. Laubenheimer	DG Research, European Commission
Michael Sterner	Research Center for Energy Networks and Energy Storage, OTH Regensburg University AS
Monti Antonello	E.ON Research Center, RWTH Aachen
Peter Lürkens	RWTH Aachen University, Center FEN
Pio Lombardi	Fraunhofer Institute IFF Magdeburg
Piotr Rumniak	S.A.M. Polska Sp. z o.o.
Roland Hermes	RWE Deutschland AG
Simon Koeppl	Forschungsstelle für Energiewirtschaft e.V.
Simon Koopmann	RWTH Aachen University - Institute for High Voltage Technology
Stefan Kippelt	TU Dortmund University
Toni Goeller	MINcom Smart Solutions GmbH
Wolfgang Normann	E.ON SE
Wolfram Krause	Younicos AG
Wulf Albrecht Engl	Engl-Energie

[12] Only the attendees having agreed to have their names listed in the minutes of the workshops are included.

9.2 Minutes of the debates

9.2.1 Session 1

Questions/discussions following the presentation of Wolfram Krause, Younicos.

- Technical aspects of the batteries were discussed, as well as their costs: Wolfram Krause explained that batteries' annual OPEX could represent up to 10% of their CAPEX. The batteries used by Younicos could reach a lifespan of 20 years with 1 cycle per day.
- The importance of the power electronics (PE) design for the integration of storage technologies in the network design were discussed. The participants concluded that fossil energies can compensate the economic losses (at MV for instance) related to renewables generation and storage integration: negative prices have been mentioned.

Questions/discussions following the presentation of Dr.-Ing. Christian Folke, Uniper.

- Christian Folke was questioned about the ICT infrastructure implemented, costs and requirements: he explained that IT safety requirements lead to the installation of a new IT connection as the existing infrastructure was not in line with the requirements.
- The lack of regulation for storage services remuneration (for instance, from DSOs) in Germany was debated.

Questions/discussions following the presentation of Dr. –Ing. Pio Alessandro Lombardi, Fraunhofer Institute for Factory Operation and Automation IFF, Magdeburg.

- General questions were raised concerning the batteries integration and interaction within the PV Park at Neuhardenberg.
- Pio Alessandro Lombardi was questioned about the different scenario simulations and their implementation in the project: hybrid business models were considered, i.e. using locally produced electricity for the auxiliaries and selling electricity to the market.

9.2.2 Roundtable 1

- The regulation issues in Germany related to storage integration, the viability of the different business cases and the lack of incentives for new market players were debated. Grid flexibility at distribution level was discussed: storage is seen as a major flexibility solutions to be supplemented by other flexibility sources (demand-side management or reinforcing the existing grid with new lines and/or installing PE devices to better control the power flows).
- The audience debated about the necessity of new investments in the distribution grid: grid operators explained that today they do not see the need for a massive integration of batteries to provide systems services for network operation.
- Wolfram Krause insisted that storage integration should progressively be taken into account for network planning studies since storage could bring many benefits such as voltage regulation. The attendees debated about the ownership of storage devices: Christian Folke pointed out that there is a biased competition between market players and the regulated players with regard to the management of storage assets.

9.2.3 Session 2

Questions/discussions following the presentation of Stefan Kippelt, Technische Universität Dortmund.

- Stefan Kippelt was questioned about the business models employed when operating a pooling various flexibility options (*Virtual Energy Storage*): the evaluation of different coordination and communication strategies together with the development of new business models for municipal utility companies were discussed.
- It was concluded that the market potential for such solutions primarily depend on the regulatory framework and pricing components.

Questions/discussions following the presentation of Prof. Monti Antonello, E.ON Research Center, RWTH Aachen.

- The reasons for switching to DC solutions at MV and LV levels were enumerated: high efficiency, the possibility of operating point to point DC links in the AC distribution grid to provide meshed topologies and better control of power flows, and the direct coupling of an increasing number of appliances operating in DC mode.
- Shortcomings of DC solutions were debated, i.e. protection devices for DC circuits in homes and the need for DC-DC converters and DC breakers in the MV grid.

Questions/discussions following the presentation of Krzysztof Czernek, S.A.M. Polska Sp. z o.o.

- Commercialization and technical aspects concerning EV batteries' deployment were discussed: fast charging properties, grid connection, batteries' optimisation conditions, BMS and EMS, etc.

Questions/discussions following the presentation of Dr. –Ing. Pio Alessandro Lombardi, Fraunhofer Institute for Factory Operation and Automation IFF, Magdeburg.

- The ADELE AA-CAES concept was presented: this solution could be an alternative for medium to large-scale storage with well-known limitations: uncertainty on the real costs, characteristic ramp rates that could limit commercial applications to secondary and tertiary reserves, need to develop specific turbines.
- The lifespan and the cycling of the different components was also identified as a topic for further research.

9.2.4 Round table 2

- Pros and cons of switching to DC grids both at transmission and distribution levels were discussed extensively: safety issues, complexity, dispatching and interoperability. DC solutions at distribution level could provide new degrees of freedom for the operations (voltage and power flow control). The experts agreed that hybrid AC/DC distribution grids could be an efficient solution for the smart grid's transition in the coming years: power electronics could supplement the existing "flexibility toolbox" so as to optimize network operations and maintenance.
- Remarks about the regulatory frameworks in Germany were made: emphasis was put on the need for standardized communication protocols and the exchange of services between DSOs and the new market payers (aggregators and storage asset operators for instance).

9.2.5 Session 3

Questions/discussions following the presentation of Simon Koopmann, Team Leader Distributed Energy Systems, RWTH Aachen University.

- Simon Koopmann was questioned about the profit generated with the envisaged business models: the participants agreed on the need for a multifunctional storage operation as a promising strategy to generate profits (provided that proper incentives are put in place within a clear regulatory framework).
- According to Simon Koopmann, for local applications, forecasts and forecast quality are major issues when portfolios include RES and need improvement and future research.

Questions/discussions following the presentation of Markus Meyer, TU München.

- Markus Meyer presented new solutions for the improved integration of PV in distribution grids, viz. the development of novel electrical equipment with extended features regarding voltage control and compensation of harmonics and the integration of the new electrical equipment into automatic superordinated control via broadband-powerline (BPL).
- Most of the technical discussion were devoted to the Unified Power Flow Controller (UPFC) and also the system approach (interactions between components and the different regulations).

Questions/discussions following the presentation of Prof. Michael Sterner, Research Center for Energy Networks and Energy Storage, OTH Regensburg University AS.

- Prof. Sterner presented the whole picture of the *EnergieWende*, i.e. use the gas grid for the large scale storage of green electricity (coupling of the electricity and gas grids with power-to-gas technologies) and fuel supply for the transport sector.
- Advantages and requirements of power-to-X (gas but also heat) coupled to RE production (especially wind production in northern German) were debated. The audience agreed that the entire system's business models should integrate all the new technologies with a multiservice scope: generation, consumption, storage, transportation, etc.
- The attendees also discussed the deployment of EVs' vs gas powered vehicles. They agreed that using existing (gas) grid infrastructure makes economic sense since there is an issue of public acceptance for new (electricity) grid infrastructures.

9.2.6 Round table 3

- The participants agreed on the need to assess storage technologies as a possible flexibility option among other solutions (generation, grid, demand). They also pointed out that hybrid storage devices (Virtual Storage Power Plants) could help better integrate storage in the distribution grid.
- The necessary evolution of the grid codes has been highly expressed. System's complexity and its evolution could be improved with market's competition and regulation, i.e. how to create a market for flexibility solutions.
- The participants (and particularly DSOs) pointed out that solutions at TRL 9 for manufacturers are not at TRL 9 for network operators (system and integration issues).

9.3 Lessons learned from the workshop

These lessons and recommendations have been discussed and agreed upon during the final roundtable.

9.3.1 Impacts of the new knowledge presented by the ten projects onto the GRID+STORAGE roadmap

The projects presented covered a large range of maturity levels for network operators, from TRL 3 for some applications to TRL 9 for some others.

Storage as a flexibility option will mainly impact the following DSO clusters in the roadmap:

- Operations,
- Market Design,
- Integration of DER and new uses,
- Integration of smart customers.

9.3.2 Integration of smart consumers Recommendations for future R&I activities and regional investments about grid and energy storage solutions

The following statements must be considered in the selection of the R&I activities for the future integrated roadmap:

- BESS: there is a need to better estimate the monetization of the benefits brought by storage for the investors and also for society as a whole (social welfare)
- Standardized communication protocols between storage devices–EMS-network operators to meet requirements from network operators (including cybersecurity).
- Power Electronics (PE) bring new horizons in terms of control of the future smart grids, including storage integration. More R&I activities are needed to understand the complex system dynamics of power systems with large PE penetration. A distinction between distribution and transmission networks should be made.
- There is still a need for focused demonstration projects (with a set of specific applications) so as to understand how storage can be optimally integrated in the power system. Collaborations between the industry (manufacturers) and the storage operators and the network operators such as network operators should be encouraged.
- Multiservice business models for storage integration might be a solution provided that the system services brought by storage are fairly valued and remunerated (regulations and market mechanisms to be studied and implemented).
- Second-hand automotive battery for stationary applications: battery pack selection, BMS as well as costs of BoS to be considered.
- Dynamic pricing should be further investigated since it might be needed to trigger participation of storage in flexibility markets.
- Hybrid AC/DC grids are a possible option to better control power flows in the distribution networks. Research is however needed for safety at LV level (especially in homes) and for power flow management at MV/HV level (multi-terminal issues).
- Research is needed to appraise the level and penetration rate of DC technologies in AC grids, and related transformation path(s).

- DSOs will increasingly perform power flow management (voltage profiles) and equip HV/MV/LV networks with adequate advanced automation schemes. The regulatory framework, operational procedures and the ICT infrastructure concerning distribution grids remains to be defined, especially the interactions between the different stakeholders.
- Accuracy of RES generation forecast is still an issue.
- Storage is one flexibility option: R&I activities are needed to compare storage with other flexibility means (interconnections, demand management, connections with other energy networks, etc.) CBA tools should include not only economics but also environmental and social aspects (LCA).
- Power-to-gas/heat is a solution to couple grids with other energy (gas, heat) networks for power, transport and heating applications while providing a large scale storage solution ensuring the necessary flexibility. Power2gas technologies are still an issue.

9.4 Projects willing to join the Knowledge Sharing Platform

A general invitation to join the GridInnovation-online community and submit their respective projects was proposed to all the speakers and the workshop participants.

10 Workshop 9 (Ireland, UK)

The ninth workshop was held in London (England) on the 15th of March, 2016. The workshop agenda is available on the Grid+Storage website.

10.1 Projects and participants in the workshop

10.1.1 R&I projects presented

Twelve R&I projects were presented during the ninth workshop, as displayed in Table 26 below.

Table 26 – Projects presented at the ninth knowledge sharing workshop

Project	Country	Purpose	Speaker	Link to presentation
Domestic & Grid Storage in WPD.	UK	Presentation of the SoLa project (Bristol): batteries (and EMS) for solar energy storage, DC networks in demonstration sites with smart tariffs approach. WPD's storage installations trials in Milton Keynes were described. Analysis of UK south west network constraints, different UK load profiles and current storage applications of WPD.	*Faithful Chanda & Mark Dale, Western Power Distribution*	Link

Lessons from RES energy storage projects in operations and construction.	UK	Presentation of RES's storage facilities (in operation and construction) and some projects: lessons learned of different (technologic, financing and lifespan) Li-ion batteries' aspects.	*Dr. John Prendergast, RES*	Link
Smarter Network Storage: Results from the first UK grid-scale multi-purpose application of battery storage.	UK	Presentation of the Smarter Network Storage Project, a multi-purpose application of storage: novel optimisation and control systems for storage, business models' analysis and regulation (market barriers) evaluation. Support activities at different voltage levels: peak shaving, frequency regulation, reactive power support, reserve capacity and tolling.	*Dr. Panagiotis Papadopoulos, UK Power Networks*	Link
Platform expansion from the UK's largest battery storage array.	UK	Presentation of AES's activity in Europe and all over the world. Demonstration of a proven technology with a complete and viable business case. Analysis of storage situation in UK during 2016.	*Dominique Laurent, AES*	Link
EirGrid investigates storage technologies	Ireland	Presentation of EirGrid storage activities in Ireland: different storage technologies and multiple demonstration projects.	*Alan Kennedy, EirGrid*	Link
Integration and Control of Energy Storage in Distribution Networks: Simulation, experimentation and deployment.	UK	Integrated modelling: batteries, power convertor and grid models (power flow management and ancillary services). In addition, presentation of storage large-scale demonstration projects, hybrid energy storage systems and the introduction of the Newcastle University Energy Storage Test Bed.	*Prof. Phil Taylor, Newcastle University*	Link
MASLOW: UK case studies on large scale pilots of Residential Energy Storage and aggregate	UK	Presentation of the commercial Moixa technologies: the Maslow battery and the GridShare platform. A practical storage solution adaptable for any home with a VPP providing multi grid services: analysis, control and trading.	*Simon Daniel, Moixa energy holdings*	Link

VPP grid services.				
Could Electric Heaters be Europe's cheapest Storage Option?	UK	Presentation of GlenDimplex low carbon solutions and large-scale demonstration projects. The Quantum Energy System: power-to-heat, in-home energy systems aggregation, demand-side management and frequency response services.	*Gerard Finneran, GlenDimplex*	Link
Grid Scale Liquid Air Energy Storage.	UK	Liquid air energy storage (LAES) presentation: process, commercialisation, benefits, economic analysis, system's characteristics and configuration. Introduction of a LAES pre-commercial demonstrator.	*Dr. Gareth Brett, Highview Power*	Link
Storage - a System Operator Perspective.	UK	National Grid's perspective and strategy about grid's transformation (storage integration): system's challenges, potential roles, economic benefits, commercial and regulatory barriers.	*Dr. Cathy McClay, National Grid*	Link
The Business Case for Energy Storage.	UK	Results from a project on opportunities from the deployment of energy storage: benefits from flexibility, multi-service approach, economic analysis (different business cases) and market, regulatory and technological barriers.	*David Sanders, Carbon Trust*	Link
Virtual Storage – multi-energy systems.	Ireland	Presentation about energy systems integration importance and virtual storage: benefits, challenges, opportunities and large-scale demonstration examples.	*Prof Mark O'Malley, UCD*	Link

10.1.2 Roundtables

The first three roundtables were mainly devoted to questions for the representatives of the presented projects. The fourth one aimed at summarizing the debates and analysing the impacts of the presented projects onto the R&I topics to be selected in the integrated roadmap. Table 27 below shows the participants in each roundtable.

Table 27 – Participants in roundtables at the ninth knowledge sharing workshop

Roundtable nr.	Participants
1	• Faithful Chanda, Western Power Distribution

	• Mark Dale, Western Power Distribution • Dr. John Prendergast, RES • Dr. Panagiotis Papadopoulos, UK Power Networks • Dominique Laurent, AES • Alan Kennedy, EirGrid • Nick Heyward, Origami Energy • Eric Peirano, Project Manager of Grid+Storage, TECHNOFI
2	• Prof. Phil Taylor, Newcastle University • Simon Daniel, Moixa energy holdings • Gerard Finneran, GlenDimplex • Dr. Gareth Brett, Highview Power • Eric Peirano, Project Manager of Grid+Storage, TECHNOFI
3	• Dr. Cathy McClay, National Grid • David Sanders, Carbon Trust • Prof Mark O'Malley, UCD • Eric Peirano, Project Manager of Grid+Storage, TECHNOFI
4	• All participants (plenary discussion) • Eric Peirano, Project Manager of Grid+Storage, TECHNOFI

10.1.3 List of attendees

In total, the workshop was attended by 95 participants, listed in Table 28 below. [13]

Table 28 – Attendees in the ninth knowledge sharing workshop

NAME	COMPANY
Aaron Gillich	LSBU
Adrian Alford	Corac Energy Technologies
Adriano Sciavovelli	University of Birmingham
Alan Kennedy	EirGrid
Allan Schroeder Pedersen	Technical University of Denmaark
Amish Poonyth	University of Reading
Andrew Aldridge	Green Angel Syndicate
Andrew Urquhart	Loughborough University
Andy Ford	lsbu
Cathy McClay	National Grid
Chris Dent	Durham University
Chris Smith	National Grid
Christophe Boisseau	ERDF
Christos Keramisanos	UK Power Networks Services
Chun Ann Huang	University of Oxford
Dagoberto Cedillos	Open Energi
Daniel Hernández Maldonado	TECHNOFI
David Sanders	Carbon Trust
Dominique Laurent	AES
Emma Gibson	Highview Power Storage
Eric Peirano	TECHNOFI
Erik Rakhou	Baringa Partners

[13] Only the attendees having agreed to have their names listed in the minutes of the workshops are included.

Faithful Chanda	Western Power Distribution
Fei Teng	Imperial College London
Francisco Cubillo	Green Power Technologies
Frank Gordon	REA
Gareth Brett	Highview Power Storage
Gerard Finneran	GlenDimplex
Giorgio Castagneto Gissey	UCL Energy Institute
Gokhan Guler	EVERON Energy
Goran Strbac	Imperial College
Graeme Dawson	RWE npower Ltd
Helena Navarro	University of Birmingham
Ian Brocklebank	The University of Sheffield
Ilias Tsagas	University of Greenwich
Jacob Allinson	RWE Generation UK
Jacqueline Edge	Imperial College London
James Bamford	EIT Digital
Jane Dennett-Thorpe	Dept of Energy and Climate Change
Jesus Nieto Martin	Cranfield University
Jill Cainey	Electricity Storage Network
Jim Marshall	Open Energi
John Perry	Denchi Power
John Prendergast	Renewable Energy Systems Ltd
Jonathan Radcliffe	University of Birmingham
Josep Morato	Parson Brinckerhoff
Konstantinos Pierros	ENERCON GmbH
Kotub Uddin	WMG, University of Warwick
Kris Kessels	VITO
Laura Dale	EDF
Liz Varga	Cranfield School of Management (SoM)
Luis Arenas Martinez	University of Southampton
Manu Ravishankar	Carbon Trust
Mark O'Malley	University of Dublin
Mark Dale	Western Power Distribution
Mark Howitt	Storelectric Ltd
Martin Foster	Sheffield University
Michael Lain	WMG, University Of Warwick
Mick Barlow	S&C Electric Company
Milijana Odavic	University of Sheffield
Nick Heyward	Origami Energy
Nikita Hall	University of Warwick
Oliver Schmidt	Imperial College London
Panagiotis Papadopoulos	UK Power Networks
Panayiotis Romanos	CREST/Loughborough University
Phil Taylor	Institute for Sustainability
Remi Boulineau	Open Energi
Richard Evans	REEC Ltd
Richard Luke	University of Oxford
Roberto Moreira	Imperial College London
Rory McCarthy	Ofgem
Ross Irvine	Brookfield Renewable
Sally Fenton	DECC

Sheridan Few	Imperial College London
Simon Daniel	Moixa
Simon Agamah	City University London
Solmaz Moshiri	EDF Energy R&D UK Centre
Stephan Marty	KiwiPowered
Stuart Norman	E.ON UK plc
Suzanne Ellis	Johnson Matthey
Szilvia Doczi	ARUP
Tiago Rodrigues	Imperial College London
Walter Sweeting	Jaguar Land Rover
Wei Sun	University of Edinburgh
Xiaomian Baxter	SSE

10.2 Minutes of the debates

10.2.1 Roundtable 1

During the first session, there were five presentations: two from market players (AES and RES) and three from regulated players (WPD, UK Power Networks and EirGrid).

- Market players insisted on the maturity of energy storage technologies (particularly BESS) for deployment at the MW/MWh ratios and pointed out the lack of a clear market and regulatory framework to foster business opportunities. In particular, market mechanisms and the associated regulatory framework should be put in place, viz. (in the UK): create contracts of sufficient length to support new asset deployment, enable layering of multiple value streams and review and update grid connection access and charging methodologies.
- Regulated players (network operators) stressed the need to further explore (with real-life demonstration projects) the added-value of energy storage in order to understand how BESS could improve network operation (system services). This would help in turn to understand the value of storage across the electricity system and therefore the profitability of the associated business cases.
- All participants stressed the lack of knowledge regarding the real lifespan of batteries in operations, i.e. when the cycling profiles are different from those used in the factory tests (standard cycling profiles). Market players specified that, usually, battery manufacturers (and suppliers) require a close estimate of the cycling profiles before committing because of warranty policies.
- All participants also discussed the issue of ownership by regulated operators. TECHNOFI gave a feedback on the position of the EC presented during a previous workshop (in Madrid): regulated operators could own and operate storage assets but within a very precise framework (to improve the management of the network). This position was challenged by the market players: system services should be provided by non-regulated players so as to foster competition and encourage the participation of new players in the electricity markets.
- The UK market structure and its regulation were commented. The need of new business cases related to new storage services and with a multi-service approach was put forward. The power supply contract's length issues in the UK were mentioned: the requirement of long-term power supply contracts which consider technology deployment and its optimization was explained.

- When deploying distributed storage technologies (i.e. BESS at the end-user premises), the customer's engagement is a major issue which directly impacts the success of the demonstrations.
- Finally, the attendees discussed about the need to address storage integration in the power system at different spatial and time scales in order to provide the needed system services (e.g. frequency control –time scale is key whereas location is not- and congestion management –location is key and timescale is of minor importance-). The participants also agreed on the need to couple the power system with other energy networks (e.g. gas and heat) so as to provide additional flexibility options for network operators and new business opportunities for market players. When comparing to the German case (power-to-gas technologies at a very large scale for transport and heating), the participants pointed out that in the UK, decarbonisation by massive electrification in the building sector was more likely to occur.

10.2.2 Round table 2

During the second session, there were four presentations: three from market players (Moixa energy holding, GlenDimplex and Highview Power) and one from a university. The speakers presented other technologies than BESS, i.e. hybrid technologies (combining BESS, flywheel and supercapacitors), heaters and liquid air storage.

- It was argued that there is a need for an integrated approach to storage (several technologies addressing different time scales and deployed at different spatial scales) so as to make multiple services commercially attractive. However, as pointed out by the university of Newcastle, this will require accurate forecasting tools (both consumption and intermittent generation) as well as advanced control algorithms optimising the need of the grid under several constraints (market, system services, technical limitations, forecast).
- Two market players (Moixa and GlenDimplex) insisted on the advantages of distributed storage: faster to deploy behind the meters at the end user premises (homes), generation of multiple revenue streams since it can be easily scaled-up (aggregated) via Internet with specific software solutions, new business opportunities for market players of the retail markets.
- The speakers also insisted on the need to consider other technologies than BESS: a 5MW LAES commercial demonstrator (to be operated in 2016 for one year) was presented, the main advantages of this technology being fast ramp up time scales and operation at atmospheric pressure.
- The AC/DC adaptability and compatibility of the Maslow integrated module was discussed. Several questions were raised regarding the software used by Moixa for their VPP and data management procedures: Maslow's cloud cluster advantages and data security issues were debated. Simon Daniel from Moixa insisted on the ability of such system when deployed at large scale to help solve local network constraints at distribution level. Simon Daniel specified that there is no specific insurance policy issues in the UK when deploying systems integrating batteries in homes, contrarily to other EU countries.

10.2.3 Round table 3

During the third session, there were three presentations: one from a market player (Carbon Trust), one from a university (UCD) and one from a regulated player (National Grid). The speakers insisted on the benefits brought by energy storage, especially virtual storage, in the UK power system and the availability of (business) solutions to overcome the barriers that currently prevent its wider deployment.

- Network operators insisted on the opportunities brought by storage so as to deliver value to the consumer and ease the transition to a decarbonised economy. However, they pointed out that it is merely one of a number of flexibility tools which can deliver value to the system and to the end consumer. They also specified the development of an appropriate market framework to incentivise flexibility is a necessary condition.
- The need to consider storage in an integrated way (energy system integration) was explained: electricity can be stored at very large scale in buildings (thermal mass of buildings) -typical time scale ~ hours-, in district heating/cooling systems – typical time scale ~ days- and in the gas grid -typical time scale ~ months-.
- Regarding the barriers that currently prevent the wider deployment of energy storage, Carbon Trust explained that they do not require significant subsidy to be removed: clear demonstration projects are required to test business cases, prove the technology and inform policy and regulatory bodies.
- The participants discussed the overall economic (and technical efficiency) of the unbundling of the power system arguing that it has created complexity which generate business opportunities but makes the system more difficult to optimise and sometimes to operate.
- The participants insisted on the need to address storage issues for the whole energy system and not only for the power system, i.e. renewable integration must be tackled with power-to-X technologies.
- The energy efficiency policies in the building sector (new and refurbished buildings) were questioned: on the long term, zero (or positive) energy buildings will create consumption profiles that might not bring the foreseen flexibility options when integrating renewable electricity.

10.3 Lessons learned from the workshop

These lessons and recommendations have been discussed and agreed upon during the final roundtable.

10.3.1 Impacts of the new knowledge presented by the twelve projects onto the GRID+STORAGE roadmap

The projects presented covered a large range of maturity levels for network operators, from TRL 4 for some applications to TRL 9 for some others.

Storage as a flexibility option will mainly impact the following TSO and DSO clusters in the roadmap:

- Planning,
- Operations,
- Market Design,
- Integration of DER and new uses (DSOs),
- Integration of smart customers (DSOs).

10.3.2 Integration of smart consumers Recommendations for future R&I activities and regional investments about grid and energy storage solutions

The following statements must be considered in the selection of the R&I activities for the future integrated roadmap:

- There is a need to better estimate the monetization of the benefits brought by storage for the investors and also for society as a whole (social welfare).

- There is still a need for focused demonstration projects (with a set of specific applications) so as to understand how storage can be optimally integrated in the power system.
- Multiservice business models for storage integration might be a solution provided that the system services brought by storage are fairly valued and remunerated (regulations and market mechanisms to be studied and implemented).
- There is a lack of proper regulatory (and market) mechanisms for the non-regulated players investing in storage.
- The operation and 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 (which is key when addressing storage issues).
- The use of automated local thermal energy storage devices and local BESS (consumer level) by market players (aggregators, retailers) so as to provide system services for network operators should be further investigated.
- There is a wide portfolio of storage technologies which fulfill different functionalities. Hybrid systems (flywheel-BESS-supercap) could help to cover wider ranges of functionalities. Other storage technologies such as LAES can provide ancillary services at MV/HV level.
- Storage is one flexibility option: R&I activities are needed to compare storage with other flexibility means (interconnections, demand management, connections with other energy networks, etc.). CBA tools should include not only economics but also environmental and social aspects (LCA).

10.4 Projects willing to join the Knowledge Sharing Platform

A general invitation to join the GridInnovation-online community and submit their respective projects was proposed to all the speakers and the workshop participants.