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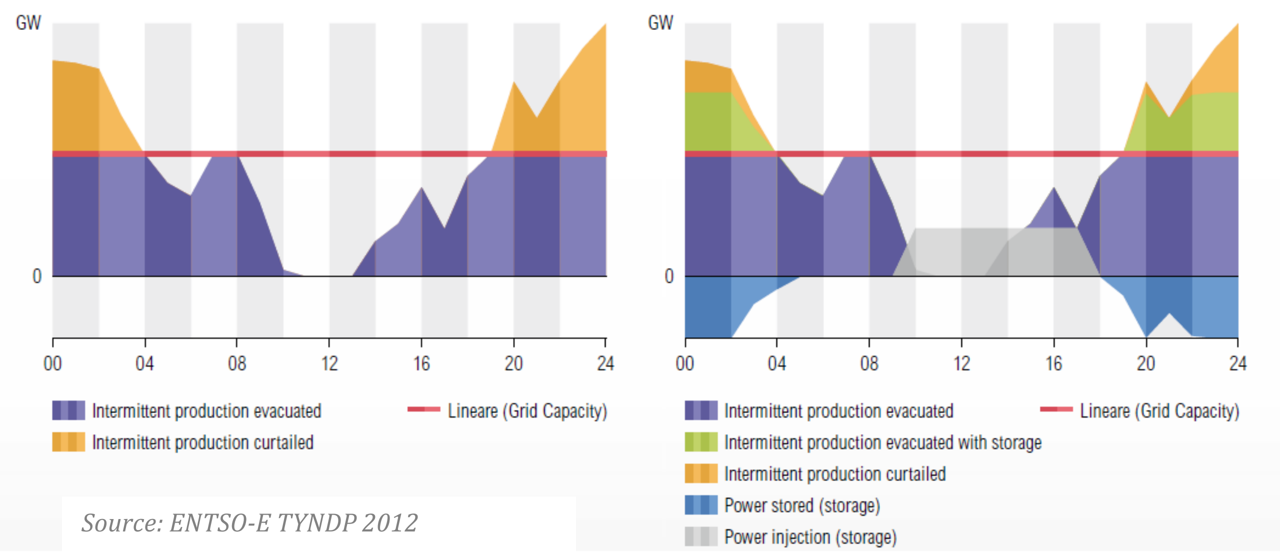
Facilitating energy storage to allow high penetration of intermittent renewable energy

European Regulatory and Market Framework for Electricity Storage Infrastructure

Analysis, stakeholder consultation outcomes and recommendations for the improvement of conditions

*Deliverable 4.2 – **Draft Version (April 2013)***



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The work for this report has been coordinated by CENER and WIP

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List of Abbreviations

ACER	…	Agency for the Cooperation of Energy Regulators
BSP	…	Balance Service Provider
CAES	…	Compressed Air Energy Storage
CBA	…	Cost Benefit Analysis
CCS	…	Carbon Capture and Storage
CEF	…	Connecting Europe Facility
CSP	…	Concentrated Solar thermal Power
DSO	…	Distribution System Operator
EC	…	European Commission
ENTSO-E	…	European Network of Transmission System Operators for Electricity
ES	…	Electricity Storage
ESF	…	Electricity Storage Facilities
ESS	…	Electricity Storage System
EU	…	European Union
FG	…	Framework Guidelines
GW	…	Giga Watt
GWh	…	Giga Watt hour
IEM	…	Internal Energy Market
MS	…	Member States
MW	…	Mega Watt
MWe	…	Mega Watt electric
MWh	…	Mega Watt hour
NC	…	Network Codes
NRA	…	National Regulatory Authority
PCI	…	Projects of Common Interest
PHES	…	Pumped Hydro Energy Storage
PV	…	Photovoltaics
RES-e	…	Electricity from Renewable Energy Sources
SET-Plan	…	European Strategic Energy Technology Plan
TSO	…	Transmission System Operator
TYNDP	…	Ten Year Network Development Plan

Executive Summary

This report aims to identify the key elements of the European market framework that potentially create unfavourable conditions for the development and operation of electricity storage infrastructure and provide policy makers with recommendations for possible improvements. A more detailed analysis on a national level will be conducted as part of the future work of stoRE (WP5) for the target countries of the project (Austria, Denmark, Germany, Greece, Ireland and Spain). The project mainly focuses on bulk storage technologies, e.g. PHES and CAES, however the framework conditions are very similar for storage technologies of smaller scale as well and therefore the recommendations in this document cover a wider spectrum of electricity storage technologies. The report is structured into three main parts.

Section 2 briefly presents some of the main directives, policies, funding instruments and other kind of initiatives, highlighting the sections relevant to electricity storage. Overall, most of the policies and Directives have direct references to electricity storage, recognising its importance and potential role in the future electricity system. However, there is no concrete support foreseen for electricity storage projects, and no concrete framework for their operation, starting from the absence of a definition for electricity storage, resulting in their treatment as normal generation systems in most cases.

Section 2.1 deals with the on-going efforts and processes for the completion of a Single Energy Market for Europe. The Electricity Directive, ACER's Framework Guidelines and ENTSO-E's Network Codes are briefly presented, highlighting the most relevant sections. Overall, the following documents have been reviewed:

- The Electricity Directive - Directive 2009/72/EC
- Framework Guidelines on Capacity Allocation and Congestion Management for Electricity
    - Network Code on Capacity Allocation and Congestion Management
- Framework Guidelines on Electricity Balancing
    - Network Code on Balancing
- Framework Guidelines on Electricity Grid Connections
    - Network Code on Requirements for Grid Connection
    - Network Code on Demand Connection
- Framework Guidelines on Electricity System Operation
    - Network Code for Operational Security
    - Network Code on Operational Planning and Scheduling
    - Draft Network Code for Load-Frequency Control & Reserves Network
- Better Governance for the Single Market - COM(2012) 259
- Making the Internal Energy Market Work - COM(2012) 663

In section 2.2 the energy infrastructure package is discussed, as an enabler for the development of the Single Energy Market for Europe. The following documents have been reviewed:

- Blueprint for an integrated European energy network - COM(2010) 677
- Guidelines for trans-European energy infrastructure - COM(2011) 658
- Establishing the Connecting Europe Facility - COM(2011) 665
- The Ten Year Network Development Plan (TYNDP)
- The list of “projects of common interest” (PCIs)

Finally, Section 2.3 focuses on the main policies, directives and other initiatives directly related to renewable energy. The following documents have been reviewed:

- The Renewable Energy Directive - Directive 2009/28/EC
- Energy 2020 - COM(2010) 639
- The European Strategic Energy Technology Plan’s (SET-Plan) as expressed in COM(2009) 519
- The Energy Roadmap 2050 - COM(2011) 885
- Renewable Energy: a major player in the European energy market - COM(2012) 271

Section 3 presents and discusses the views of all stakeholder groups as expressed during a wide consultation process, which comprises:

- Development of a questionnaire and supporting document after deeply reviewing the European Directives and Policies
- Distribution of documents to selected experts and feedback for improvements
- Distribution of final documents to stakeholders (including the industry, utilities, civil and environmental NGOs, governmental organisations and EC officials) by e-mail
- Contact by telephone with selected experts
- Four round tables where the main concerns regarding regulatory aspects at a European level as well as the first draft results were discussed
- Experts input during the project’s 2nd advisory board meeting
- Collection and analysis of feedback from overall 55 experts

The collected feedback was grouped in four sub-sessions: Current business model, regulatory framework, market design and other regulatory and market issues and discusses the different points of views, presenting the arguments supporting each position. This section covers the business model and marginal viability of electricity storage systems in the current framework, discussing whether the marginal viability reflects that there are more efficient solutions for balancing. Also the following issues are examined: the market distortions that could affect the price signals, the applicability of the unbundling principle on electricity storage, the energy infrastructure package and the role that storage projects should have in it and other issues like grid fees, network codes, etc.

Section 4 presents some recommendations from the stoRE project team, based on the work presented in sections 2 and 3, for adapting the market design in order to facilitate the development of the electricity storage infrastructure, to the extent necessary for accommodating the future development of variable renewable energy. The recommendations are summarised here:

Recommendations to the European Commission:

1. Re-evaluate the exemption of the PHES from the financing provision of the infrastructure package, restricting only financing to plants that could be profitable without support, or plants that might have important environmental impacts.

2. Officially clarify the applicability to electricity storage of the unbundling principle (Article 9(1) of the Electricity Directive), by including a clear definition of electricity storage in the Directive and involving all stakeholders in a dialogue to come up with an approach that fulfils the following conditions:

- Ensure the functioning of an open, fair and transparent market, by introducing clear restrictions to the use of electricity storage facilities by system operators if and when they are allowed some kind of control over them.
- Facilitate the market selection of the most efficient solution when a decision has to be taken for transmission vs. storage.

3. Maintain the possibility to include in the PCI also projects not foreseen in the TYNDP, at least as long as TSOs are not allowed to control electricity storage and as a result such projects do not feature in the TYNDP.

4. Introduce targeted regulatory interventions and initiatives in order to deal with the cause or the effects of market distortions and ensure the timely development of storage infrastructure to the extent necessary to facilitate the continuous growth of renewable energy. Here are listed some ideas proposed in this direction that could form a basis for further consideration:

- In future revisions of renewable energy support mechanisms elements could be introduced that reward flexibility.
- Provide some kind of support for renewable electricity storage, for example granting priority dispatch to the stored electricity stemming from RES and exempting this electricity from any grid fees and taxes.

5. Monitor the transposition to national legislation of Electricity Directive Article 15 (7) for transparent and market based mechanisms for balancing and encourage the integration of mechanisms on the national level that will ensure adequate market liquidity for providing the necessary services to balance the grid.

Recommendations to ACER and ENTSO-E:

1. Include definitions of electricity storage in the network codes, covering also small scale systems with the potential to become elements of the smart grid developments, in order to facilitate the development of similar administrative procedures in the Member States for their connection to the grid.

2. Develop a method to calculate grid fees that will be taking into account the real impact of the electricity storage system on the grid, as in most cases storage systems are not contributing to congestion problems, but are actually relieving them.

3. Apply common rules across Europe regarding grid fees in order to avoid deployment of a project in one country and provision of services in another, only because of different framework conditions.

4. Critically review the Cost Benefit Analysis methodology developed for the evaluation of the proposed Projects of Common Interest to ensure that it is fair and treats electricity storage projects in equal terms with transmission projects.

<u>Recommendations to project developers and other stakeholders involved with electricity storage:</u>

1. Closely monitor the on-going development of the network code on balancing in order to ensure that electricity storage facilities will gain full access to cross border markets.

2. Monitor the transposition to national legislation of Electricity Directive Article 15 (7) for transparent and market based mechanisms for balancing and encourage the integration of mechanisms on the national level that will ensure adequate market liquidity for providing the necessary services to balance the grid.

3. Critically review the Cost Benefit Analysis methodology developed for the evaluation of the proposed Projects of Common Interest to ensure that it is fair and treats electricity storage projects in equal terms with transmission projects.

1. Introduction

The objective of the stoRE project is to facilitate the development of electricity storage in order to allow greater penetration of variable renewable energy. One of the principal issues influencing further development of electricity storage is the regulatory and market framework conditions. In this report, these aspects are studied on a European level, defined through relevant directives, policies, funding instruments or other kind of initiatives. The report aims to provide policy makers with recommendations for adapting the current or planned regulations and market structure taking into account unnecessary negative effects on the development of energy storage infrastructure. A more detailed analysis on a national level will be conducted as part of the future work of stoRE (WP5) for the target countries of the project (Austria, Denmark, Germany, Greece, Ireland and Spain).

This report focuses on the two main bulk Electricity Storage Technologies (EST), Pumped Hydro Energy Storage (PHES) and Compressed Air Energy Storage (CAES), but most of the discussions and recommendations are also applicable to other electricity storage technologies.

Methodology

The procedure the stoRE team has followed to develop this report comprises:

- Development of a questionnaire and a supporting document after reviewing the European Directives and Policies.
- Distribution of these documents to selected experts who provided feedback for improvements of the questionnaire and the supporting document
- Distribution by e-mail of the questionnaire and the supporting document to representatives of the industry, utilities, civil and environmental NGOs, governmental organisations and EC officials
- Four round table discussions with different target groups where the main concerns regarding regulatory aspects at a European level as well as the first draft results were discussed
- Experts input during the project's 2nd advisory board meeting
- Drafting of the report, including analysis of the feedback and formulation of recommendations
- A final round of feedback collection from representatives of the industry, utilities, civil and environmental NGOs, governmental organisations and EC officials

More specifically, a review of the main relevant European documents related to market and regulatory aspects was carried out in order to highlight the main challenges and concerns affecting the deployment of electricity storage systems in Europe. A summary was prepared and discussed with 23 stakeholders during the first two Round Tables to determine the main aspects concerning the different stakeholders and list some specific questions related to them. A draft of the questionnaire was sent to 4 selected contacts to improve it and the final version was sent together with a supporting document to about 120 contacts and was uploaded in the stoRE web page for public participation. Feedback was collected by a big range of stakeholders including industrial associations, developers, law firms, NGOs, regulatory authorities, research institutes, TSOs, utilities, etc. The first draft results from the consultation process were discussed with 30 stakeholders during the third and the fourth Round Tables and more stakeholders were approached by email right after that in order to allow the finalisation of the work and the drafting of final policy recommendations.

The first Round Table was carried out in Wroclaw (Poland) during the HIDROENERGIA Conference on the 25th of May 2012. A presentation and a discussion based on a questionnaire took place with the participation of 15 attendees. The questionnaire was later distributed among the attendees by e-mail and feedback was gathered and analysed as a preliminary input for the consultation process. The second Round Table was carried out in Brussels (Belgium) during the EU Sustainable Energy Week on the 20th of June 2012. A presentation and discussion took place with the participation of 8 attendees. The minutes were distributed among participants and used as basis for following steps of the process. The third Round Table took place in Brussels (Belgium) within a meeting with the members of the Hydro Working Group of Eurelectric on the 20th of February 2013. A presentation and discussion took place with the participation of 14 attendees. The fourth Round Table took place in Brussels (Belgium) within a meeting with the members of ESHA (European Small Hydropower Association) on the 27th of March 2013. A presentation and discussion took place with the participation of 16 attendees.

Structure of the Report

This report is structured into four chapters. Chapter 2 briefly presents some of the main directives, policies, funding instruments and other kind of initiatives that are relevant to electricity storage, highlighting the relevant sections. Chapter 3 discusses the different points of view on the topic received after a wide consultation process with stakeholders. Finally Chapter 4 comes up with recommendations for possible future improvements of the regulations and market structure, based on the inputs from the consultation process.

2. European Regulatory and Market Framework

This section highlights the relevant parts of the European directives, policies, funding instruments and other kind of initiatives that could affect the development and operation practices of electricity storage facilities.

Section 2.1 deals with the on-going efforts and processes for the completion of a single energy market for Europe. In section 2.2 the energy infrastructure package is discussed, as an enabler for the development of the single energy market for Europe. Finally, Section 2.3 focuses on the main policies, directives and other initiatives directly related to renewable energy.

2.1 Development of a single energy market for Europe

The process of developing a single energy market for Europe started already in in 1996 with the Directive 96/92/EC[1] which defined common rules for the creation of an internal market for electricity. Then in 2003 in order to deal with shortcoming and to improve the functioning of the market, Directive 2003/54/EC[2] was adopted. Finally in 2009, in order to further open and integrate the energy market, Directive 2009/72/EC[3] was adopted, which is referred to as the Electricity Directive and is part of the "EU third energy package".

As part of the third energy package, also the institutional framework was affected. The Agency for the Cooperation of Energy Regulators (ACER) and the European Network of Transmission System Operators for Electricity (ENTSO-E) were established. ACER was mandated according to Regulation (EC) No 713/2009 to propose Framework Guidelines[4], based on which, ENTSO-E develops legally binding network codes (Regulation (EC) No 714/2009)[5] for cross-border network and market integration issues, without prejudice to the Member States' right to establish national network codes which do not affect cross-border trade.

In the following sections the Electricity Directive and the Framework Guidelines and Network Codes will be briefly presented, highlighting the most relevant sections.

2.1.1 The Electricity Directive

The Directive 2009/72/EC concerning common rules for the internal market in electricity establishes common rules for the generation, transmission and distribution of electricity.

The Directive includes a list of definitions regarding power generation, transmission,

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[1] Directive 96/92/EC
[2] Directive 2003/54/EC
[3] Directive 2009/72/EC
[4] Regulation (EC) No 713/2009
[5] Regulation (EC) No 714/2009

distribution and supply terms but the concept of electricity storage is not mentioned in the document. Therefore, the Directive fails to include ESS as a separate component in the energy model. The result is that ESS is generally treated as a generation system.

Furthermore in Article 9 (1) it is defined that a TSO cannot control supply or generation of electricity (*"directly or indirectly to exercise control over a transmission system operator or over a transmission system, and directly or indirectly to exercise control or exercise any right over an undertaking performing any of the functions of generation or supply"*). As explained above ESS is not defined as a separate component of the system, therefore it is treated as an electricity generator. Consequently a TSO cannot control an electricity storage system, as long as this is used part of the time to supply electricity. However, Article 44 (2) defines exceptions: *"Article 9 shall not apply to Cyprus, Luxembourg and/or Malta".*

The Directive also addresses the dispatching and balancing issues requiring in Article 15 (3) to give priority to electricity from renewable sources (see also Article 16 of Directive 2009/28/EC[6]). In Article 15 (7), transparent market based mechanisms are promoted for balancing: *"Rules adopted by transmission system operators for balancing the electricity system shall be objective, transparent and non-discriminatory, including rules for charging system users of their networks for energy imbalance. The terms and conditions, including the rules and tariffs, for the provision of such services by transmission system operators shall be established pursuant to a methodology compatible with Article 37(6) in a non-discriminatory and cost-reflective way and shall be published."*

Article 37 (6) requires the national regulatory authorities to ensure that balancing tariffs are non-discriminatory and cost-reflective, while providing appropriate incentives to network users for balancing their input and off-takes: "*the provision of balancing services which shall be performed in the most economic manner possible and provide appropriate incentives for network users to balance their input and off-takes. The balancing services shall be provided in a fair and non-discriminatory manner and be based on objective criteria*".

2.1.2 Framework Guidelines and Network Codes

The European Commission invites ACER to develop framework guidelines, which set out general principles for the rules that regulate, who may use the electricity networks to transport energy across borders and under which conditions. Network codes are then drafted by ENTSO-E in coherence with the principles that ACER sets out in the framework guidelines. Network codes can be made legally binding by a separate Commission decision.

Figure 2.1 shows the current (April 2013) progress and planning for the development of framework guidelines and network codes.

[6] Directive 2009/28/EC

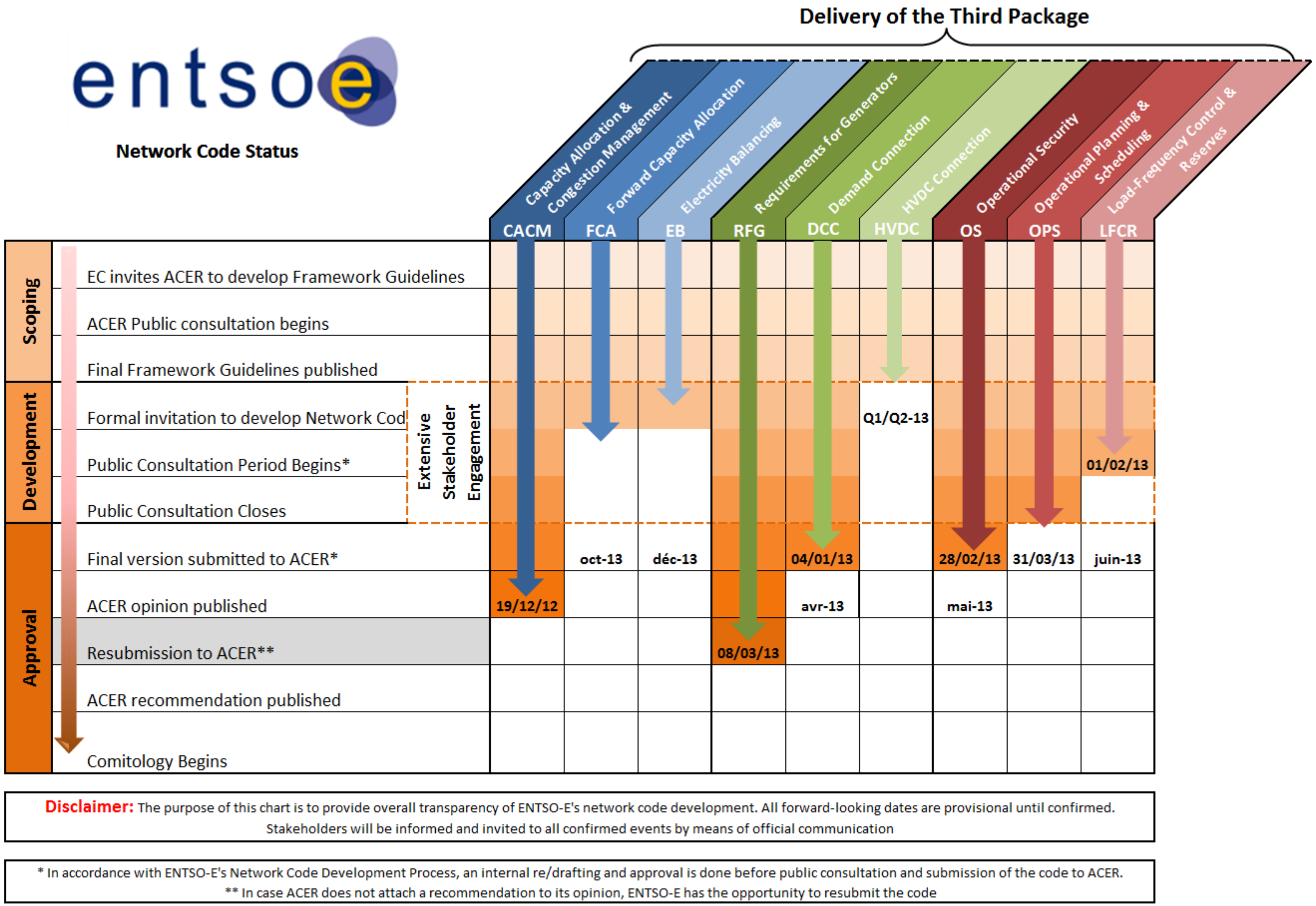

Figure 2.1: Current progress and planning for the development of framework guidelines and network rules (source: ENTSO-E)

Capacity Allocation & Congestion Management

The Framework Guidelines on Capacity Allocation and Congestion Management for Electricity[7] were adopted on the 29th of July 2011. Based on this the **Network Code on Capacity Allocation and Congestion Management**[8] has been developed and was submitted to ACER on the 27th of September 2012. *"This Network Code sets common rules for Capacity Allocation and managing cross Bidding Zone congestion in the Day Ahead and Intraday Markets. This will involve the establishment of common methodologies for determining the volumes of capacity simultaneously available between Bidding Zones and methodologies for defining Bidding Zones".* On the 14th of March 2013, ACER issued a Recommendation to the European Commission (EC) to adopt the Capacity Allocation and Congestion Management Network Code. In a letter to the EC, ENTSO-E welcomed the finalisation of the Agency's Recommendation and stressed its support for several well-balanced proposals. However, ENTSO-E also expressed concerns about 4 areas of the recommendation, which ENTSO-E considers they may negatively affect the feasibility and quality of the implementation of the EU target model.

Also a ***Network Code on Forward Capacity Allocation*** is currently under development, but no drafts have been published yet.

Balancing

The Framework Guidelines on Electricity Balancing[9] were adopted on the 18th of September 2012. They *"address the roles and responsibilities of stakeholders involved in electricity balancing, the procurement of frequency restoration reserves and replacement reserves, the activation of balancing energy from frequency restoration reserves and replacement reserves, and the imbalance settlement"*.

In these Framework Guidelines, ACER intends to limit TSOs responsibility strictly on organising balancing markets in the most effective and efficient manner and encourage cooperation with each other in order to achieve this. With regards to which market player shall provide the required balancing services it is mentioned: *"The Network Code on Electricity Balancing shall require that each TSO is responsible for procuring the required balancing services from BSPs* (Balance Service Providers) *and is not allowed to offer the balancing services itself except, subject to NRA's* (National Regulatory Authority) *approval, if system security is threatened due to insufficient bids from BSPs".*

The first full preliminary draft **Network Code on Balancing**[10] has been completed and further issues will be discussed with regulators and stakeholders through organised meetings and workshops prior to, during and after a public consultation. Previously, ENTSO-E published its

[7] Framework Guidelines on Capacity Allocation and Congestion Management for Electricity
[8] Network Code on Capacity Allocation and Congestion Management
[9] Framework Guidelines on Electricity Balancing
[10] Network Code on Electricity Balancing - DRAFT

Survey on Ancillary Services Procurement and Electricity Balancing Market Design[11], which provides an overview of the different market arrangements in place throughout Europe. This highlights the great diversity of arrangements that exist, which is a challenge when designing cross-border balancing schemes in the balancing code.

Electricity Grid Connections

The Framework Guidelines on Electricity Grid Connections[12] were adopted on the 20th of July 2011. Based on this, the Network Code on Requirements for Grid Connection applicable to all Generators[13] was finalised and submitted on the 8th of March 2013 including a set of amendments based on items addressed in ACER's earlier reasoned opinion. On the 27th of March 2013, ACER issued a recommendation to the European Commission to adopt the Network Code. Based on the same Framework Guidelines, also a final version of the Network Code on Demand Connection[14] was submitted on the 21st of March 2013, awaiting ACER's reasoned opinion, which is due in early April 2013. Finally, early work on the *Network Code on HVDC Connection* has just started.

The **Network Code on Requirements for Grid Connection** *"defines a common framework of grid connection requirements for Power Generating Facilities, including Synchronous Power Generating Modules, Power Park Modules and Offshore Generation Facilities. It also defines a common framework of obligations for Network Operators to appropriately make use of the Power Generating Facilities' capabilities in a transparent and non-discriminatory manner ensuring a level-playing field throughout the European Union."*

In this Network Code storage is taken into account and is treated in the same way as other generating devices with the same characteristics. The main focus has been on pumped hydro storage systems:

> *"Pump-storage Power Generating Modules shall fulfil all requirements in both generating and pumping operation mode. Synchronous Compensation Operation of Pump-Storage Power Generating Modules shall not be limited in time by technical design of the Power Generating Modules. Pump-Storage variable speed Power Generating Modules shall fulfil all requirements applicable to synchronous Power Generating Modules and in addition those set forth in Article 15(2) (b), if they are of Type B, C or D."*
>
> *"With regard to disconnection due to under-frequency, any Power Generating Facility being capable of acting as a load except for auxiliary supply, including hydro Pump-Storage Power Generating Facilities, shall be capable of disconnecting its load in case of under-frequency."*

The **Network Code on demand connection** *"defines a common set of requirements for*

[11] Survey on Ancillary Services Procurement and Balancing Market Design
[12] Framework Guidelines on Electricity Grid Connections
[13] Network Code on Requirements for Grid Connection applicable to all Generators
[14] Network Code on Demand Connection

Transmission Connected Distribution Networks and Significant Demand Facilities, to be connected to the Network and sets up a common framework for Network Connection Agreements between Network Operators and the Demand Facilities Owner or Distribution Asset Owner". Here storage is also taken into account, where:

> *"A storage device within a Demand Facility or Closed Distribution Network (excluding hydro pump-storage) operating in electricity consumption mode is considered to be a Demand Unit."*
>
> *"Any pump-storage Power Generating Module which has both generating and pumping operation mode does not have to meet the requirements of this Network Code.*
>
> *Any pumping module within a pump-storage station which only provides pumping mode is subject to the requirements of this Network Code."*

As mentioned earlier, a **Network Code on HVDC Connection** is also expected to be prepared in the future and some initial work has already started.

Electricity System Operation

The Framework Guidelines on Electricity System Operation[15] were adopted on the 2nd of December 2011. Based on these framework guidelines the final Network Code for Operational Security[16] was submitted on the 28th of February 2013 to ACER which will provide a reasoned opinion as to whether the code is in-line with the framework guidelines within the next 3 months. Based on the same Framework Guidelines, also the Network Code on Operational Planning and Scheduling[17] has been submitted on the 29th of March 2012 to ACER which will provide a reasoned opinion as to whether the code is in-line with the framework guidelines within the next 3 months. Finally a preliminary draft Network Code for Load-Frequency Control & Reserves Network[18] has been published on the 4th of July 2012, a public consultation has finished and ENTSO-e will analyse the response and use this input to finalise the code.

The **Network Code for Operational Security** defines *"the minimum Operational Security requirements and principles for transmission systems applicable to all TSOs, relevant DSOs and Significant Grid Users"*.

The **Network Code for Operational Planning and Scheduling** defines *"the minimum Operational Planning and Scheduling requirements for ensuring coherent and coordinated preparation of real-time operation of the transmission system applicable to all Transmission System Operators and Distribution System Operators as well as Significant Grid Users."*

The **Network Code for Load-Frequency Control & Reserves Network** (LFCR) focuses on

[15] Framework Guidelines on Electricity System Operation
[16] Network Code on Operational Security
[17] Network Code on Operational Planning and Scheduling
[18] Network Code for Load-Frequency Control & Reserves Network - DRAFT

frequency quality criteria, frequency control structure, frequency containment reserves, frequency restoration reserves, replacement reserves, exchange of reserves and synchronous time control. These LFCR provisions will also help to ensure efficient utilization of infrastructure and resources.

2.1.3 Progress with the implementation of the IEM

In a European Commission communication COM(2012) 259[19] in June 2012 a number of legislative acts have been identified that require enhanced efforts and commitments "*from both the Member States' and the Commission's side, to make the Single Market function to its full potential"*. Among them the Electricity Directive is identified, as 13 Member States have not fully transposed the Directive.

Then in November 2012 a communication was adopted COM(2012) 663[20] addressing specifically the progress with the internal energy market. In this communication there is importance placed on storage, already in the introduction: *"we urgently need to invest in generation, transmission and distribution infrastructure, as well as storage."*

The communication is also stating that price signals are the tool for *"encouraging flexibility on the supply side, from storage or from generation capacity that can be quickly ramped up or down"*. Then it is clearly stated that the EC intends to tackle any regulatory issues in the integration of storage: *"The Commission will as a matter of priority…help speed up the integration of storage and flexible generation e.g. by tackling remaining regulatory issues in the context of the European balancing market network code. The Commission will consider setting up a co-ordination initiative to address emerging regulatory and technical issues. Its upcoming communication on energy technologies and innovation will analyse how technology development, including storage technology and micro-generation, could link up with market developments at the European level to achieve the climate and energy targets."*

It is also acknowledged that *"The swift adoption and implementation of the Energy Infrastructure Package is crucial"*. Regarding pumped hydro the transparency in awarding concessions is addressed: *"…The most appropriate way should be to put these concessions out to tender on a non-discriminatory basis, using open instruments such as auctions"*.

2.2 European Energy Infrastructure Planning

2.2.1 The Energy Infrastructure Package

In November 2010, an EC communication was adopted on energy infrastructure priorities for 2020 and beyond - A Blueprint for an integrated European energy network, COM(2010) 677[21]

[19] COM(2012) 259
[20] COM(2012) 663
[21] COM(2010) 677

outlining a vision of what is needed for making our networks efficient.

On 19 October 2011, the European Commission adopted two relevant proposals for Regulations, which together comprise the energy infrastructure package:

- "Guidelines for trans-European energy infrastructure" COM(2011) 658[22] (repealing Decision No 1364/2006/EC)
- “Establishing the Connecting Europe Facility” COM(2011) 665[23]

The "**Guidelines for trans-European energy infrastructure**" proposal aims at ensuring that strategic energy networks and storage facilities are completed by 2020. To this end, the Commission has identified 12 priority corridors and areas covering electricity, gas, oil and carbon dioxide transport networks. It proposes a regime of "common interest" for projects contributing to implementing these priorities and having obtained this label.

In general storage has a prominent position in the proposed regulation as it is always mentioned together with transmission. However, in Article 14 (1) regarding Incentives and 15 (2) regarding Financial Assistance the most mature storage technology of pumped-hydro is specifically excluded:

Also in Annex I where *Energy Infrastructure Priority Corridors and Areas* are identified there is no reference to storage. In Annex II on the other hand, when defining the 5 *Energy Infrastructure Categories* relevant for electricity, storage facilities connected to high-voltage transmission lines are foreseen: *“electricity storage facilities used for storing electricity on a permanent or temporary basis in above-ground or underground infrastructure or geological sites, provided they are directly connected to high-voltage transmission lines designed for a voltage of 110 kV or more”.* However, as explained above, pumped hydro projects, which is the main technology used today for that purpose is explicitly left out of the option to receive any financial support or incentive to be developed.

Also in order to get the "common interest" label a project shall, among others:

- contribute significantly to market integration, interoperability and system flexibility (measured in line with the analysis made in the latest available ten-year network development plan in electricity)
- be part of the latest available ten-year network development plan for electricity, developed by the ENTSO for Electricity
- for electricity storage, the project provides storage capacity allowing a net annual electricity generation of at least 500 GWh

The “**Establishing the Connecting Europe Facility**” proposal sets out the provisions governing the proposed integrated instrument for investing in EU infrastructure priorities in Transport, Energy and Telecommunications: the "Connecting Europe Facility" (CEF).

[22] COM(2011) 658
[23] COM(2011) 665

2.2.2 The Ten Year Network Development Plan

On the 5th of July 2012, the Ten Year Network Development Plan (TYNDP)[24] was completed by ENTSO-E and submitted to ACER. This is relevant to the energy infrastructure package, as for projects to be labelled for "common interest" they have to be foreseen in the TYNDP. However, the TYNDP foresees mainly transmission projects. As for now, there are only 15 projects among them that have relevance to storage and these concern just the connection of pumped hydro power plants and not their development.

However, the importance of storage is highlighted in a dedicated full page text box (page 84), recognising that storage is a complementary and not competitive approach to grid development: *"As a conclusion, storage facilities might be a complement, and not an alternative way, to the grid development in order to allow: resolution of grid congestions, peak shaving, reserve for the electricity system and primary frequency regulation."*

Also in section 21.5.2 *"Overview of Available or Promising Technologies Today"*, there is a passage on electricity storage, which again emphasises that it *"could have a significant impact on transmission planning and operations".* In the same section, interestingly they raise the issue of which players shall own and manage storage facilities: *"In terms of regulatory issues, open questions are related to which players (private market operators contributing to system optimization or regulated operators) shall own and manage storage facilities. Implementing large scale demonstrations of storage solutions at European level appears to be a necessary step to validate both storage benefits based on full scale studies and the potential asset ownership options for storage regulations."* With this statement it seems that for ENTSO-E the interpretation of Article 9 (1) of the Electricity Directive (see section 2.2.1) is an open issue.

The next target for the TYNDP is the release of the next Ten-Year Network Development Plan in June 2014.

2.2.3 Projects of Common Interest

The Union-wide list of "projects of common interest" (PCIs) is expected to be established for the first time in 2013 and then updated every two years. The identification of PCIs is based on a regional approach in line with the identified priority corridors. To this end, ad hoc working groups have been established to identify potential PCIs, each group covering one priority corridor as set out in Annex I of the draft Regulation.

As mentioned in section 2.3.1 all potential PCIs have to be in the Ten Year Network Development Plans (TYNDP) of ENTSO-E. However, for the first Union-wide list of PCIs[25], the selection process was different and the Commission coordinated a request for information on behalf of the working groups also for projects not included in the latest TYNDP. Then, from

[24] Ten Year Network Development Plan

[25] List of projects submitted to be considered as potential PCIs in energy infrastructure

June to October 2012 a consultation process was organised to seek views on the list of all the projects that have been submitted to be considered by the ad hoc working groups as potential PCIs

This preparatory process in 2012 is based on the engagement of all parties and is necessary to ensure rapid selection of PCIs once the Regulation has entered in to force, in view of regulatory measures and possible financing as early as 2014.

The latest available version[26] (amended 27th of July 2012) of the proposed PCIs for electricity contains more than 170 proposed projects. About 20 of them contain a storage element, with half of those being normal pumped hydro projects (new or refurbishments), 4 seawater pumped hydro projects, 2 CAES, 2 with batteries and one CSP with thermal storage. In Annex I the projects with a storage element from the preliminary PCI list are provided. However, no assessment has been done on any of the projects, so the list is only indicative and it remains to be seen how many of the storage projects will make it to the final list.

2.3 Energy Policy and Support for Renewables

2.3.1 The Renewable Energy Directive

The Directive 2009/28/EC[27] of 23 April 2009 (amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC) sets ambitious and binding targets for all Member States, such that the EU will reach a 20% share of energy from renewable sources by 2020. It also improves the legal framework for promoting renewable electricity, requires national action plans that establish pathways for the development of renewable energy sources and creates cooperation mechanisms to help achieve the targets cost effectively.

The Directive foresees that the Member States will develop national renewable energy action plans (NREAP), planning the development up to 2020. Indeed all 27 Member States have submitted these plans within 2010.

Regarding storage, first the Directive clarifies that *"electricity produced in pumped storage units from water that has previously been pumped uphill should not be considered to be electricity produced from renewable energy sources",* something that was already clear from the 2001 Renewable Energy Directive.

The Directive also recognises the need for supporting electricity storage: *"There is a need to support the integration of energy from renewable sources into the transmission and distribution grid and the use of energy storage systems for integrated intermittent production of energy from renewable sources."*

[26] List of projects submitted to be considered as potential PCIs in energy infrastructure - Electricity
[27] Directive 2009/28/EC

More specifically Article 16 (1) requests Member States to ensure development of infrastructure, including storage, that will ensure secure integration of renewable electricity: *"Member States shall take the appropriate steps to develop transmission and distribution grid infrastructure, intelligent networks, storage facilities and the electricity system, in order to allow secure operation of the electricity system as it accommodates further development of electricity production from renewable energy sources, including interconnection between Member States and between Member States and third countries".*

2.3.2 Energy 2020 – A strategy for competitive, sustainable and secure energy

The "Energy 2020" Communication (COM(2010) 639)[28] identifies the energy priorities for the period up to 2020, i.e. to reduce energy consumption, implement the internal market, develop infrastructure, improve technology, protect consumers and reinforce the external dimension of energy policy.

Regarding storage, under priority number 4, the second proposed action foresees ambitious storage projects for bringing Europe at the driver's seat regarding the relevant technology development: *"Re-establishing Europe's leadership on electricity storage (both large-scale and for vehicles). Ambitious projects will be developed in the fields of hydro capacity, compressed air storage, battery storage, and other innovative storage technologies such as hydrogen. These will prepare the electricity grid at all voltage levels for the massive uptake of small-scale decentralised and large-scale centralised renewable electricity".*

2.3.3 The European Strategic Energy Technology Plan

The European Strategic Energy Technology Plan's (SET-Plan) objective as expressed in the COM(2009) 519[29] and the staff working document SEC(2009) 1295[30] is to "*bring together industry, the research community, the Member States and the Commission in risk-sharing, public-private partnerships aiming at the rapid development of key energy technologies at the European level".*

There are 8 European Industrial Initiatives included in the SET-Plan but there is no specific initiative related to electricity storage technologies. Still storage is mentioned in the documents relevant to the European Electricity Grid initiative, the Solar Initiative and the Wind Power Initiative.

In the first months of 2012 and as a part of the activities included in the SET-Plan, the Education and Training Initiative was launched with the objective to determine the human resource needs for the different technologies including Energy Storage. On the 9th of March 2012 the kick off meeting to start the activities related to the development of a report to be

[28] COM(2010) 639
[29] COM(2009) 519
[30] SEC(2009) 1295

used by the Commission as a basis for a European Communication took place. This report will include the following issues:

- Section 1: Current situation – existing workforces (value chain), labour intensity, future trends, and workforces required to achieve the SET-Plan vision.
- Section 2: On-going actions
- Section 3: Needs and gaps, in particular main barriers or bottlenecks for the different industrial sectors and their markets
- Section 4: Recommendations at EU and MS level within specific target dates

2.3.4 Energy Roadmap 2050

The Energy Roadmap 2050, COM(2011) 885[31] is the basis for developing a long-term European framework together with all stakeholders. It explores routes towards decarbonisation of the energy system and has developed different scenarios with different shares of renewable energies *"examining the impacts, challenges and opportunities of possible ways of modernizing the energy system".*

Regarding storage the analysis of the scenarios concludes that *"Storage technologies remain critical. Storage is currently often more expensive than additional transmission capacity, gas backup generation capacity, while conventional storage based on hydro is limited. Greater efficiencies in their use and competitive costs require improved infrastructure for integration across Europe. With sufficient interconnection capacity and a smarter grid, managing the variations of wind and solar power in some local areas can be provided also from renewables elsewhere in Europe. This could diminish the need for storage, backup capacity and base load supply."*

It also recognises that: *"One challenge is the need for flexible resources in the power system (e.g. flexible generation, storage, demand management) as the contribution of intermittent renewable generation increases... Ensuring that market arrangements offer cost-effective solutions to these challenges will become increasingly important. Access to markets needs to be assured for flexible supplies of all types, demand management and storage as well as generation, and that flexibility needs to be rewarded in the market. All types of capacity (variable, base load, flexible) must expect a reasonable return on investment."*

In the same section it also confirms the current approach of working with ACER on developing the best approach on this issue: *"Building on the 3rd internal energy market package, the Commission, assisted by the Agency for the Cooperation of Energy Regulators (ACER), will continue to ensure that the regulatory framework stimulates market integration, that enough capacity and flexibility are incentivized, and that the market arrangements are ready for the challenges decarbonisation will bring. The Commission is examining the effectiveness of different market models for remuneration of capacity and flexibility and how they interact with*

[31] COM(2011) 885

increasingly integrated wholesale and balancing markets."

The document concludes with 10 conditions that must be met for achieving a new energy system. One of the ten conditions is: *"A new sense of urgency and collective responsibility must be brought to bear on the development of new energy infrastructure and storage capacities across Europe and with neighbours"*.

2.3.5 Renewable Energy support after 2020

In an effort to start planning renewable energy policy developments after 2020 and to give some clarity to the relevant stakeholders, the EC has issued in June 2012 the communication: Renewable Energy: a major player in the European energy market, COM(2012) 271[32].

"This Communication explains how renewable energy is being integrated into the single market. It gives some guidance on the current framework until 2020 and outlines possible policy options for beyond 2020, to ensure continuity and stability, enabling Europe's renewable energy production to continue to grow to 2030 and beyond."

In section 3, about the electricity market opening it is confirmed once again that a market based approach to encourage the necessary flexibility is chosen: *"The market should be able to respond, reducing supply when prices are low and increasing it when prices are high. Changes in market prices need to encourage flexibility, including storage facilities, flexible generation and demand-side management (as consumers respond to changing price patterns)."*

Also in chapter 6 regarding technology innovation, it is recognised that: *"It would appear that notably ocean technologies, energy storage, advanced materials and manufacturing for renewable energy technologies need to be given higher priority in future research."*

[32] COM(2012) 271

3. Discussion of Input from Relevant Stakeholders

3.1 Current Business Model

Feasibility

Historically, large scale electricity storage plants were developed for storing electricity from base load plants during the night and supplying it during the daytime peak. Most of these plants were developed before the market liberalisation, but they have been able to operate profitably also in the open market based on the spread between off-peak and peak prices. Over the last years though the spreads in various Member States have been decreasing, which can be at least partly attributed to high generation by RES. This is resulting to reduced revenue for electricity storage plants.

The electricity storage facilities can have additional income streams that vary depending on the Member State in which they are operating. For example electricity storage facilities can participate in reserve markets, ancillary services markets and balancing markets. For these markets there is a variety of procurement and remuneration mechanisms across Europe including mandatory provision, bilateral contracts, tendering or the use of the spot market. In some cases they might be able to benefit from capacity payments or use portfolio effects if owned by utilities with various generation assets. But the revenues from these additional income streams are not always transparent and it is difficult to foresee how they will develop as they depend on fast evolving regulatory, market and technical variables. In regards to that, a report developed within the THINK project mentions: *"The difficulty for external investors, especially for those not being incumbent generators, to know the value of storage for providing the ancillary services could partially be due to the lack of data and knowledge about the ancillary services procurement and remuneration. This lack of data and knowledge is sometimes related to the adoption of bilateral contracts not accessible for a third party"* [33].

Many respondents to our survey have claimed that at the moment it is uneconomic to build new pumped storage power plants, the most developed large-scale electricity storage technology. This view is also backed by some studies and reports[34]. Even when developers are willing to invest in large electricity storage facilities, they explain that access to finance is difficult because of the various regulatory and market uncertainties that could affect negatively their profitability.

In section 3.3 we will examine views as to whether this lack of viability reflects the fact that the services provided by electricity storage can be procured at lower cost by other technologies at sufficient quantity and quality or if they can be partly attributed to a malfunction of the market.

[33] S. Ruester, J. Vasconcelos, X. He, E. Chong, J.M. Glachant. *Electricity Storage: How to Facilitate its Deployment and Operation in the EU*, European University Institute, June 2012, link

[34] B. Rangoni. *A Contribution on the Regulation of Electricity Storage: the case of Hydro-Pumped Storage in Italy and Spain*. London School of Economics: link

Financial Support

Within the infrastructure package the possibility of financial support for electricity storage projects is foreseen, which could contribute towards overcoming the feasibility and financing difficulties described in the previous paragraph. But pumped hydro projects are explicitly exempted from the opportunity to seek this financial support.

Most survey respondents understand this exemption as support for technologies that are less mature in order to develop alternatives and increase the competition in the market. The development of alternatives is also important as pumped hydro can't be built everywhere due to its site-specific requirements.

However, several stakeholders feel that a level-playing field between pumped hydro and other storage technologies has to be established and therefore any support has to be open equally to all forms of storage technologies and selection has to be based only on value provided driven by capabilities such as speed of response, energy stored, etc.

Some advocate the view that the level-playing field should be achieved by removing the financial support for any type of electricity storage as it distorts competition with other options that can offer flexibility to the system. According to their view incentives should only be placed on the market side and should apply to any technology, for example in the form of a tax exemption.

3.2 Regulatory Framework

Unbundling principle

According to Article 9 (1) of the Electricity Directive a TSO cannot have any type of control over an electricity generation facility. Therefore, to the extent that electricity storage is treated within the regulatory framework as generation, a TSO cannot have any control over an electricity storage facility. The intention is to prevent incentives for abusive behaviour in the market, where for example an electricity generation facility owned by a TSO could have an advantageous treatment compared to a generation facility owned by a third party.

Several stakeholders, especially the utilities, have a very clear view of supporting the unbundling principle and its strict implementation also in the case of electricity storage, because they believe that it is in line with the open market approach that delivers the most efficient results on a system level. According to their view, as storage facilities can in effect act as a power generating unit participating in the energy market, the same incentives for abusive behaviour can potentially be present. Also for ancillary services a market based approach is foreseen or should be developed within the emerging regulatory framework.

Therefore, this group of respondents to the survey believe that control over both transmission and storage should be treated the same way as cross-ownership of transmission and generation. The role of the TSO should thus be to define the products needed for balancing and for the stability of the system and use market based mechanisms for procuring these products.

However, there is still legal uncertainty regarding the implementation of the unbundling principle on electricity storage, at least according to some respondents. They bring as an example the controversial regulation in Italy where the TSO has been allowed to own and operate batteries. Also ENTSO-E in its latest Ten Year Network Development Plan (TYNDP)[35] states that: *"In terms of regulatory issues, open questions are related to which players (private market operators contributing to system optimization or regulated operators) shall own and manage storage facilities."*

Even if some stakeholders believe that the application of Article 9 (1) of the Electricity Directive on electricity storage is absolutely clear the on-going discussion about it from the parties that do not share this view does not help electricity storage to progress in a clear framework. The unbundling principle has to be officially clarified and an explicit amendment would be preferable from a legal certainty viewpoint.

It has been recommended that a necessary first step would be to include a clear definition of electricity storage in the Electricity Directive. Then it should be decided if and how to include it in Article 9 (1) and this is open for debate.

One view already explained above is that the unbundling principle should apply also to electricity storage, strictly forbidding any kind of TSO control over electricity storage facilities. If that route is chosen the Article 9 (1) of the Electricity Directive should be reworded making that clear and stopping any further discussions on the issue, making possible to challenge the legislation in Member States that are not respecting it and allowing electricity storage to develop in a clear framework.

An alternative approach suggested by other stakeholders during the survey was to allow some kind of control by TSO/DSOs on electricity storage facilities but subject to conditions that would ensure the functioning of an open, fair and transparent market. Such conditions could be along the lines of the Article 9 (1) of the Belgian Electricity Act, i.e.:

Energy storage ownership from TSOs

"As a company transporting goods all over the world is allowed to store these goods temporarily in warehouses to exchange their means of transportation (ship to train etc.) in order to reduce the overall cost of transportation, a transmission operator should be allowed to do the same with electrical energy at the rule that goods should not be produced in the warehouses but only stored temporarily and reducing dispatching/congestion costs."

Source: Collected feedback - Representative from Research Institute

[35] Ten Year Network Development Plan 2012

(i) the electricity is generated for balancing purposes only, with an explicit prohibition for commercial purposes; (ii) the stored electricity is called upon as a last resource; (iii) under the form of negotiated drawing rights; (iv) to the limit of the power needed for ancillary services; (v) upon the prior approval of the regulator; (vi) after having completed all relevant procedures for calling upon the market.

There are also views claiming that none of the two approaches to unbundling proposed above gives the optimal technical, economic and social result on a system level. Academics for example pointed out that the strict implementation of the unbundling principle is driven by economic and political agendas, partly neglecting the technical aspects. It was explained that there are cases where in an area with high penetration of intermittent renewable energy and transmission constraints, alleviating the transmission constraints would be a more expensive solution than constructing an electricity storage facility. According to the view of these stakeholders, in such cases the current market approach would not necessarily point to the most efficient solution when a decision has to be taken for transmission capacity built by a TSO vs. storage built by an independent operator; especially when non-market types of subsidies are available for the transmission lines but not for certain types of electricity storage facilities.

Other respondents also supported the view that even with a strict implementation of the unbundling principle, TSOs still have a financial interest in market outcomes, specifically in the extent to which market outcomes rely on new investment in transmission facilities. According to them this results in lack of a fully transparent settlement of services in the balancing market and a lack of fully transparent valuation of non-transmission alternatives in the energy market, irrespective if there is a government-regulated TSO owning grid-scale electricity storage facilities or a government-regulated TSO being for all intents and purposes the only buyer of the critical services provided by grid-scale electricity storage facilities. It was also explained that this indirect financial interest of TSOs in market outcomes introduces an inherent market barrier to cost-effective distributed solutions, one that is in most cases beyond the practical limits of member-state regulators to police effectively.

According to the respondents who expressed these concerns, the deployment of resources and the procurement of system services should reside with an entity that has no financial interest of any kind in market outcomes. A system optimisation approach should be followed for the decisions regarding development of transmission lines and storage facilities, following clear and transparent criteria, which could be implemented under the supervision of ACER.

A possible alternative is shown in the case of the planned storage park in Orkney Islands, Scotland. In this case the DSO, instead of investing in additional distribution lines capacity or building its own storage facility, is tendering for "congestion management services", without defining the technology and clearly communicating congestion management requirements, demand forecast and the grid expansion plan. The THINK project report on electricity storage mentions about this example: "*The business model in this initiative will involve a third party energy storage provider delivering congestion management services to the DNO. The energy storage provider can further benefit from other commercial activities, such as ancillary services contracted with National Grid, or some arbitrage …. It is a regulated-driven business model* *without ownership by the regulated actor. The novelty is that in the tender, there is no specification of storage technology, dimension or eligible actor, but only a specification of service requirements. Congestion management requirement, as well as demand forecast and grid expansion plan for the next years are communicated to the bidders*" [36].

Definition of storage

As mentioned above, a definition of storage within the Electricity Directive would help to the clarity of the unbundling principle. There were calls for an official definition of storage also from stakeholders who see administrative barriers in certain Member States when new storage technologies want to connect to the distribution network, as there are no procedures foreseen. The definition of storage in the Directive and subsequently in all framework guidelines and network codes could pave the way for appropriate connection rules to be issued in all Member States.

3.3 Market Design

Market signals

In an ideal electricity market all the required services are well defined and there are transparent, liquid and competitive markets allowing any entities and technologies to compete for the opportunity to provide those services. This seems to be also the target of the internal Electricity Market that is under development. In such a market there would be clear signals to reflect the increased requirements for flexibility in balancing and ancillary services due to the increased penetration of intermittent renewable energy. These signals would be interpreted by electricity storage developers/operators, among others, to design, build and operate their facilities in order to capitalize on these market opportunities. Constructing an electricity storage facility with faster response times and increased ability to activate upwards and downwards reserves and provide other ancillary services involves increased capital cost. Market participants in the electricity storage sector should have clear market signals on what added income they may expect by the provision of these additional services and evaluate it against the increased capital cost.

Some stakeholders believe that within the current or upcoming market design there are adequate market signals in place: *"The mechanisms which are put into place through the electricity directives are sustainable, and provide the adequate market signals to build flexible storage without sacrificing the ever present requirement for capacity."* In their view, if pumped hydro or other electricity storage systems are not viable in certain Member States, as indicated in section 3.1, this means that there are other resources that can provide the needed services to the European energy market more efficiently.

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[36] S. Ruester, J. Vasconcelos, X. He, E. Chong, J.M. Glachant. *Electricity Storage: How to Facilitate its Deployment and Operation in the EU*, European University Institute, June 2012, link

However, others expressed the opinion that market signals alone cannot be counted upon for indicating timely the need for balancing and other ancillary services and the most efficient resources for providing these services. The reason they give for this inability of the market is the distortion of feed-in tariffs for renewable energy and the financial support for transmission infrastructure.

> Incentives and Market Distortion
>
> *"Whereas RES-e incentives are a distortion to the market, the energy storage sector which facilitates greater penetration of RES-e is not incentivized because incentives may be considered a distortion. A solution to allow greater penetration of RES-e is sought in transmission infrastructure which is also incentivized! Being monopolistic, the transmission infrastructure incentives may not distort the market but add to the cost of electricity. This fragmentation does not allow for comprehensively optimal and cost-effective solutions for the electricity sector. PHES is part of the solution and it is negatively affected by the exclusion from incentives for trans-European infrastructure. Incentives given to energy storage could save larger sums given to other solutions, such as transmission infrastructure."*
>
> *Source: Collected feedback - Representative from Regulatory Authority*

To indicate a possible market failure, one stakeholder mentioned the example of the effect that the fast growth of PV in some European markets has on the viability of electricity storage. The solar energy is covering peak power during the day resulting in a smaller spread between peak and off-peak prices, reducing one of the main electricity storage income streams. Of course this reflects the reality that solar energy currently helps to smooth the residual load curve (2nd graph in Figure 3.1) reducing the need for the traditional electricity storage role of shifting production form base load units from off-peak to peak times (1st graph in Figure 3.1).

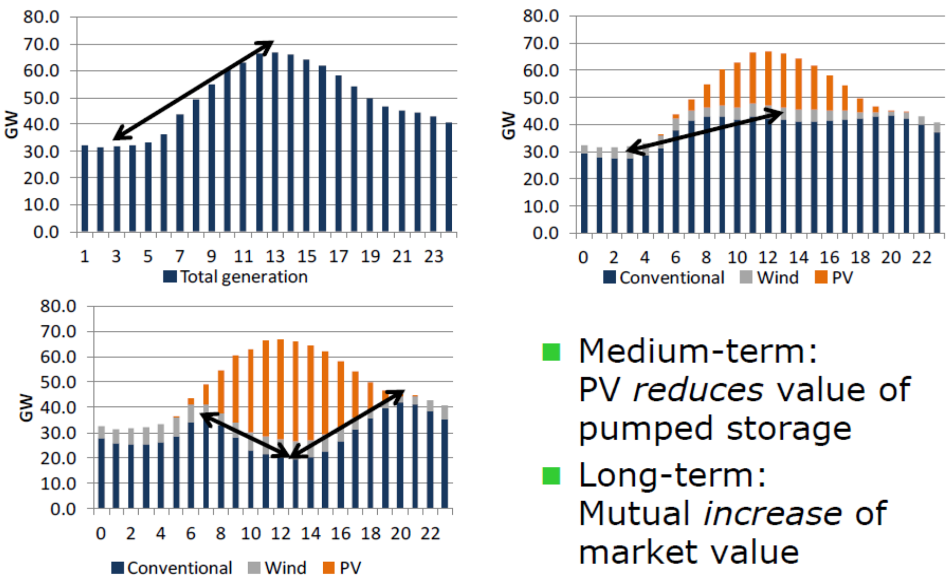

Figure 3.1: How solar energy might affect the storage requirements. Source: Simon Mueller, IEA, Future Design of RE Markets, EUFORES Parliamentary Dinner Debate, 4 December 2012, Brussels

However, as solar energy will continue to grow, the need for electricity storage will also grow again as shown in the 3rd graph of the figure below. However, currently there is no market signal pointing to this direction. But PHES, which is a mature large scale electricity storage technology, has development times that can be longer than 10 years. So, if electricity storage will be required in the period 2020 to 2030, the markets signals should be available now.

As a step to overcome this possible problem it has been suggested to use models for predicting the future electricity storage needs in order to design a suitable intervention in the market design. Apart from the fact that defining the storage needs in an objective way is a controversial issue, partly because it depends as well on the transmission capacity, there is also an important deviation on the projections for the extent, the mix and the pace of the renewable energy development in the medium and long term. As an example the table below shows the estimation of different sources for the solar capacity installed in Europe in 2030.

Source	**Installed Solar Capacity by 2030 (MWe)**
Energy Roadmap 2050 (Reference Scenario)	91,599 (PV+CSP)
Energy Roadmap 2050 (High RES Scenario)	195,255 (PV+CSP)
Eurelectric's Power Choices	65,000 (PV+CSP)
Greenpeace's Energy [R]evolution (Reference Scenario)	82,000(PV+CSP)
Greenpeace's Energy [R]evolution (Advanced Scenario)	430,000 (PV+CSP)
EPIA (Accelerated Scenario)	458,000 (PV only)
EPIA (Paradigm Shift Scenario)	768,500 (PV only)

Also the example in the text box below, with the 3 PHES systems that are under construction in Switzerland, illustrates the limitations of the market to give the appropriate signals for the kind of investments that are needed and for the characteristics that the storage or other systems that are developed to cover certain needs should have.

Energy Storage Business Model in Switzerland

"In Switzerland 3 large PHES schemes (each between 900-1000 MW) are in construction, without public support. However, the business model today remains more uncertain than when these plants were planned and designed. Initially, the business model of these plants was based on cheap nuclear electricity for the pumping and on selling peak electricity over lunch and in the evening. This business model is clearly not accurate anymore as PV feeding into the grid over lunch changes the demand for peak electricity. PHES are operated today with much more than 2 cycles a day (pumping-producing). New PHES will have to adapt accordingly their business model and maybe also review storage capacity and installed capacity (e.g. in order to produce over longer periods when no sun or no wind with less MW, instead of 2 hours of lunch with more MW)."

Source: Collected feedback - Representative from Research Institute

Of course there is a risk in any type of investment and this should be beard by the developer, who will also reap the possible benefits. However, if the risk becomes too high to justify investments when the lack of infrastructure translates to a market signal, there will not be enough time for the necessary investments.

Grid Fees

One issue that many stakeholders who participated in the survey brought up was the grid fees that electricity storage operators have to pay, which in several Member States are double, both as consumers and as generators.

It was suggested that common rules should be applied across the EU regarding transmission access fees and use of system fees for electricity storage systems in order to avoid deployment of an electricity storage facility in one Member State with favourable rules in order to provide services in another Member State with less favourable rules.

There was a relative consensus that there should be no double grid access fees and that storage should be treated as time shifted generators and not as end consumers. Some even proposed to fully eliminate grid fees for electricity that is stored solely for the purpose of re-electrification. For instance, since late 2011, Germany exempts new electricity storage facilities and PHES expansion projects for a defined period of time from grid tariffs.

Grid Fees

"But generally, charging the L-component of the grid tariff on storage is not well founded for two reasons. First, a storage unit is not the end-user of electricity (it "consumes" to store for later re-production). Second, storage operators are very elastic to price signals, more elastic than any other type of generator or consumer. More importantly, the grid tariff should be based on the principle of cost causality. If an electricity storage unit is systematically using the grid during off-peak periods (a behaviour being in line with the arbitrage business model for the charging mode), it should not be considered triggering grid investment.

Furthermore, it may reduce losses of the cable by leveling the line loading. The introduction of a time component in grid tariffs would allow for a more efficient use of the grid asset, and would certainly take into account the impact of storage units on grid investment needs."

Source: THINK Project

In addition to grid access fees, the connection fee is another issue where harmonisation across Europe and reduction/elimination of the fee would positively affect the electricity storage devices viability. The report of the THINK project on electricity storage[37] also reaches a similar conclusion as shown by the report extract in the text box above.

[37] S. Ruester, J. Vasconcelos, X. He, E. Chong, J.M. Glachant. *Electricity Storage: How to Facilitate its Deployment and Operation in the EU*, European University Institute, June 2012, link

Balancing Market

Electricity storage facilities participate in balancing mechanisms in a very effective way, as they have the ability both to absorb and inject energy to the system. Therefore, the stakeholders that participated in the survey are keen to see the full transposition of transparent and market based mechanisms promoted for balancing in Article 15 (7) of the Electricity Directive and the development of the network guidelines on balancing, allowing them to participate in cross border balancing activities. Close monitoring and participation to the development of the network code on balancing is recommended for all stakeholders that are interested to see full access for electricity storage facilities to cross border markets.

Existing Balancing Markets

"An efficient market for balancing power is fully implemented in Germany (www.regelleistung.net). Energy storage facilities have full and non-discriminatory access to this market. Therefore, there is no need for further legislative measures as the existing legislation already sets a sufficient framework. Power plants and storage systems both can do nothing more than reducing or increasing their output. Differences exist only in speed and amount of output change and in the algebraic sign of the output. Storage systems therefore do not need a special treatment in the market design. Possible capacity bonuses should apply to all market participants under equal conditions."

Source: Collected feedback - Representative from Utility Company

However, one respondent highlighted the fact that Article 15 (7) leaves regulatory uncertainty as: *"it does not make clear who is in charge of providing enough and adequate services to balance the grid; it depends on how liquid the market is, at the national, but also at the continental level. This uncertainty affects the feasibility of ESF negatively".*

Stakeholder's recommendations

It has been suggested by stakeholders participating in the survey that by introducing in the renewable energy support mechanisms elements that reward flexibility, the distortion in the market would be reduced making the market signals for flexibility and storage requirements more clear. It could lead to renewable energy generators investing to storage systems allowing them to maximise the value of their generating portfolio.

As an alternative approach it was suggested to support storage only when storing renewable excess, either by introducing some kind of feed-in-tariff or by adopting a provision granting priority dispatch to the stored electricity stemming from RES, similar to the priority that renewable electricity has according to Article 15 (3) of the Electricity Directive. For this electricity a tax and/or grid fee reduction/exemption could be also applied.

Other stakeholders, in a search for overcoming the challenges while complying with the market approach recommended considering a forward services market in which the service is bought sufficiently far forward - and no further - to be relevant to investment decisions in resources capable of providing the needed balancing and flexibility services. Another market based approach suggested are capacity payments or tenders, where the capacity contribution of electricity storage facilities will be defined according to clear and widely accepted rules.

It was also highlighted that any support would have to be carefully designed, in order not to be used to remove the pressure from base load non-CCS fossil fuel power plants, more than the market electricity storage would do it, but just to provide necessary security of the system.

Another indication that the market signals are not considered adequate for long-term investments is the fact that capacity mechanisms are considered in several European countries for peak power plants. But as the THINK report points out *"As far as the design of the capacity mechanism does not recognize possible contributions of alternative flexible means (including storage) in the capacity consolidation, the implementation of such a mechanism is likely to further dis-incentivize investments in storage as compared to peak generation units."*

3.4 Other regulatory and market issues

It was pointed out that PHES has a longer average lifetime than most other technologies and therefore, some early PHES-sites may not fulfil the increased requirements of recent grid codes. It was recommended to preserve the status quo in the framework guidelines and network codes to not unnecessarily lose PHES capacity.

Although the focus of the stoRE project and this survey is mainly on the transmission level, in our survey we have come across several comments that point to the fact that the need for storage on the distribution level is growing fast and there are important regulatory and market issues to be dealt with in order to allow the market to function for promoting the most efficient mix of technologies and pace of implementation. Some issues are similar with the transmission level and have been addressed in the previous sections, like the need to have an official definition of storage in the electricity directive and the market distortion introduced by the feed-in-tariffs for renewable energy generation.

During the survey it was also pointed out that many of the energy services fuelled by electricity involve forms of energy which themselves are far easier and more economical to store, like space heating and cooling, refrigeration, water heating and municipal water pumping. Also selective charging of vehicle batteries can be employed to increase flexibility: "*The important thing, however, is to ensure that all options for time-shifting the delivery of the end-use energy service from the production of electricity have an equal opportunity to participate in the market. Only in that way can we integrate larger shares of variable renewables at the least cost and with the least impact on reliable system operations*."

In the same wavelength were interventions like:

> *"Storage can play a role not only in generation but also in transmission, distribution and end users. Storage is a key enabler for the Smart Grid development. In case of ES behind the meter, owner may allow utilities to partially or fully control behind the meter energy storage in exchange for long-term contracts."*

> *"The market has to be open for small players too. To date in most of the MS the limit to participate in the regulatory energy market is between 1 and 5 MW"*

It was also recommended that DSOs who operate a vertical integrated local/regional grid (e.g. within smart grids) should also be able to operate electricity storage facilities within their local/regional mandate. Or, similarly to capacitor banks, some services of storages may be only attributed to the distribution grid, for instance load balancing or phase shift. DSOs may be allowed to operate storage facilities that exclusively offer these services.

4. Conclusions and recommendations

Energy Infrastructure Package – Recommendations to the European Commission

Decreasing spreads between peak and off-peak power requirements are resulting to reduced revenue for electricity storage plants. Even though they can have additional income streams from other sources like reserve and ancillary service markets, at the moment most developers claim it is uneconomic to build new bulk electricity storage plants. Also access to finance is difficult because of the various regulatory and market uncertainties that could affect negatively their profitability.

In that respect we welcome the provision of the infrastructure package to provide financial support for electricity storage projects as it could help in the timely development of storage infrastructure.

However, the explicit exemption of pumped hydro storage projects from this provision is controversial, as PHES is a mature technology that could have a major contribution to cover the electricity storage needs for the next decade. **Therefore we recommend that the exemption of the PHES from the financing provision of the infrastructure package is re-evaluated, to prohibit only financing of plants that could be profitable without support, or plants that might have important environmental impacts.**

A market oriented approach that would ensure fair remuneration and would give clear prospects of the PHES profitability is preferable and is also analysed in this report. But the re-evaluation of the energy infrastructure package terms could provide immediate results, until a Europe wide energy market is operating effectively to deliver clear price signals, giving confidence to investors.

Electricity Directive – Recommendations to the European Commission

The market based approach of balancing can be of benefit to electricity storage facilities, as they can be very effective in providing such services. Therefore, **we recommend the close monitoring and enforcement of the transposition of transparent and market based mechanisms promoted for balancing in Article 15 (7) of the Electricity Directive and encourage integration of mechanisms on the national level that will ensure adequate market liquidity for providing the necessary services to balance the grid.**

The Article 9 (1) of the Electricity Directive is interpreted by most stakeholders as a prohibition to TSOs and DSOs to exercise any control over electricity storage facilities. However, in Italy the TSO has been allowed to own and operate batteries. Also ENTSO-E in its latest Ten Year Network Development Plan (TYNDP) has a statement in which it treats as an open question the issues of which players are allowed to own and manage electricity storage systems.

The legal uncertainty is created by the fact that electricity storage is not defined in the Electricity Directive and therefore is implicitly treated as a generation facility. The on-going controversy about this issue does not help electricity storage to progress in a clear framework. **We recommend that Article 9(1) of the Electricity Directive is officially clarified regarding its applicability to electricity storage:**

The first step should be to include a clear definition of electricity storage in the Electricity Directive. We recommend that this should be done in cooperation of all relevant stakeholders like the European Association for Storage of Energy, to ensure that the definition will cover the relevant aspects of the different technologies without affecting energy storage technologies that do not have electricity both as input and as output and therefore should not be affected by the Electricity Directive.

Then it should be decided if and how to include the electricity storage in Article 9 (1) of the Electricity Directive. **We recommend that all stakeholders are involved in a dialogue to come up with an approach that fulfils the following conditions**:

- Ensure the functioning of an open, fair and transparent market, by **introducing clear restrictions to the use of electricity storage facilities by system operators** if and when they are allowed some kind of control over them
- Facilitate the **market selection of the most efficient solution when a decision has to be taken for transmission vs. storage**

In this context, we welcome the process that has started for developing Guidelines for Cost Benefit Analysis (CBA) of Grid Development Projects. In the draft version published by ENTSO-E in December 2012[38] though we see that, similarly with the TYNDP, electricity storage projects do not feature there. Instead, plans and decisions for transmission projects are evaluated taking the current and expected development scenarios for electricity storage infrastructure just as an input value. Of course most electricity storage projects might not end-up high in the ranking of the European infrastructure projects, but the methodology for evaluation should give them a fair chance to be compared to electricity transmission projects.

Projects of Common Interest – Recommendations to Project Developers, ACER and the European Commission

As explained in section 2.2.3, for the first Union-wide list of PCIs, it was allowed as an exception to have submissions also for projects not foreseen in the TYNDP. As a result, more than 10% of the projects in the draft list concern electricity storage, with most of them being pumped hydro even though they would not qualify for financial assistance. To shortlist the projects the CBA will have to be applied. **We recommend that the project developers and ACER will critically review the evaluation of the proposed electricity storage projects to ensure that it is fair and in equal terms with the transmission projects.** This is important, because as long as the transmission projects benefit from subsidies that electricity storage has no access to, the open market cannot operate to indicate the most efficient solution.

[38] ENTSO-E, Guideline for Cost Benefit Analysis of Grid Development Projects, December 2012

Also, as long as TSOs are not allowed to control electricity storage and as a result such projects do not feature in the TYNDP, **we recommend that the European Commission maintains the possibility to include in the PCIs also projects not foreseen in the TYNDP**.

Network Codes – Recommendations to ENTSO-E, ACER and Project Developers

We recommend including also official definitions of electricity storage in the network codes, covering also small scale systems with the potential to become elements of the smart grid developments, in order to facilitate the development of similar administrative procedures in the Member States for their connection to the grid.

We welcome the development of the network codes on balancing that will allow to the various players to participate in cross border balancing activities. **We recommend that the project developers and other stakeholders that are interested to see full access for electricity storage facilities to cross border markets to monitor closely the on-going development of the network code on balancing.**

Grid Fees – Recommendations to ENTSO-E and ACER

We recommend that common rules should be applied across the EU regarding transmission access fees and use of system fees for electricity storage systems in order to avoid deployment of a project in one Member State with favourable rules in order to provide services in another Member State with less favourable rules.

We also recommend that these fees will be calculated with a method that will be taking into account the real impact of the electricity storage system on the grid. Electricity storage facilities can choose when to absorb electricity from the grid and when to feed it back. In most cases they are operated for balancing so they are not contributing to congestion problems, but are actually relieving them. Therefore, a new method for calculating the grid fees in a way that the cost is allocated more fairly to the players that are causing it will reduce the operating cost of electricity storage systems, affecting positively their viability.

Internal Electricity Market – Recommendations to the European Commission

In the ideal electricity market, which is the target of the third energy package, all the required services are well defined and there are transparent, liquid and competitive markets allowing any entities and technologies to compete for the opportunity to provide those services. In such a market there would be clear signals to reflect the requirements for flexibility in balancing and ancillary services and these signals would be interpreted by electricity storage developers/operators, among others, to design, build and operate their facilities accordingly or not to build if other technologies could provide the required services at lower cost. However, there are a number of elements listed below that prevent the ideal operation of the market:

- The feed-in tariffs are not a market based tool and therefore the market based evaluation of the technologies to balance their variable nature will not necessarily give the right results
- The financial support for transmission infrastructure and for certain storage technologies is also not a market tool and adds distortions to the market based evaluation of storage projects
- The procurements of ancillary services is often based on bilateral contracts, with terms and conditions not publicly available, which does not contribute to the development of an open market
- Large scale storage systems have development times that can be over 10 years long, therefore for storage requirements in period 2020 - 2030, the markets signals should be available now

We recommend that targeted regulatory interventions and initiatives are introduced on a European level in order to deal with the cause or the effects of market distortions in order to ensure the timely development of storage infrastructure to the extent necessary to facilitate the continuous growth of renewable energy. Here are listed some ideas proposed in this direction and that could form a basis for further consideration:

- In future revisions of renewable energy support mechanisms elements could be introduced that reward flexibility
- Provide some kind of support for storage only when storing renewable excess, for example granting priority dispatch to the stored electricity stemming from RES, similar to the priority that renewable electricity has according to Article 15 (3) of the Electricity Directive and exempting this electricity from any grid fees and taxes.
- Develop a forward services market in which the service is bought sufficiently far forward - and no further - to be relevant to investment decisions in resources capable of providing the needed balancing and flexibility services. However, the deviation on the projections for the extent, the mix and the pace of the renewable energy development could make this task more difficult
- Redesign capacity mechanism in order to recognize possible contributions of alternative flexible means (including storage) in the capacity consolidation

Annex I – Proposed PCI projects with storage element

Source: http://ec.europa.eu/energy/infrastructure/consultations/doc/pci_list_electricity.pdf

Corridor	N°	Countries	Project	Description	Planned date of completion	Project promoter(s)	TYNDP reference
CEE elec	E12	AT	Obervermuntwerk II	Pumped Storage Hydro Plant with 2 units at 180 MW between the existing reservoir Silvretta (38 Mio m³) und the existing reservoir Vermunt (6 Mio m³) and a gross head of rd. 300 m. Generate each power between - 360 MW and + 360 MW. The maximum short time energy storage will be nearly 4 GWh; and a long time storage of nearly 110 GWh.	2018	Vorarlberger Illwerke AG	Non-TYNDP
CEE elec	E28	BG/EL/RO	Increase volume of the lower reservior of Chaira PSHPP	Increase of generating capacity of Chaira PSHPP by the construction of Yadenitsa Dam (lower reservoir-9 mln m3).	2020	NATSIONALNA ELEKTRICHESKA KOMPANIA EAD (NEK EAD)	Non-TYNDP
CEE elec	E114	EL	Pumped Storage Complex with two upper reservoirs: Agios Georgios and Pyrgos	Two (2) upper reservoirs will be constructed northeast, annual energy production: 264.000 MWh/year	2018	TERNA Energy, S.A.	Non-TYNDP
WE elec	E10	AT	Pumped Storage Power Plant Limberg II	In the area of the right-hand river bank, a head race tunnel, approx. 4 km long, and a 0.6 km vertical penstock handling a water volume of 144m3/s will be cut out of the rock using two tunnelling machines. For the two power units, a machine cavern 62 m long, 25 m wide and 43 m high, will be excavated from inside the rock.	2021	Verbund A.G.	Non-TYNDP
WE elec	E6	AT	Pumped Storage Power Plant Limberg III	In the area of the righthand bank, a machine cavern for the two power units will be excavated inside the rock. The approx. 5.4 km pressure tunnel and penstock for a water volume of 144m3/s will be constructed on the righthand bank, parallel to the tunnel system of Limberg II. Power transmission (energy outlet and intake) is ensured by an existing 380kV double line linking the tension insulator portal to the substation Kaprun/main stage.	2020	Verbund A.G.	Non-TYNDP
WE elec	E7	AT	Efficiency Increase Program "Zillertal Power Plant Group"	Mayrhofen power plant is to increase its turbine capacity and its annual production. The projected increase in pumping capacity at Roßhag and the production increase from the pump operation enable increasing the efficiency of the pumped storage.	2014	Verbund A.G.	Non-TYNDP
WE elec	E8	AT	Pumped Storage Power Plant Reisseck II	A newly constructed lead race channel is to supply the new power plant of the cavern type (length: 58 m, width: 25 m, height: 43 m). Another lead race channel will link the new power plant to the existing pressure tunnel of the Gösskar and Galgenbichl reservoirs (Malta group), which is connected to Rottau power station. These reservoirs of the Malta group are used as the downstream basin of Reisseck II.	2014	Verbund A.G.	Non-TYNDP

Corridor	N°	Countries	Project	Description	Planned date of completion	Project promoter(s)	TYNDP reference
WE elec	E9	AT	Pumped Storage Power Plant "Energiespeicher Riedl"	A pumped storage power plant is planned downstream from Jochenstein HPP, on the Danube.	2018	Verbund A.G.	Non-TYNDP
WE elec	E11	AT	Efficiency Programm "Malta Power Plant Group"	Major revision and repair work as well as the renewal of essential building components.	2015	Verbund A.G.	Non-TYNDP
WE elec	E13	AT	Efficiency Program Kaprun Power Plant	The peak capacity and production will be increased.	2015	Verbund A.G.	Non-TYNDP
NSOG	E149	IE/UK	Natural Hydro Energy Strategic Energy Infrastructure	Large scale pumped storage schemes on the Irish West Coast interconnected by High Voltage DC cables to the Irish and UK grid systems.	2019	Natural Hydro Energy Ltd	Non-TYNDP
NSOG	E150	IE/UK	MAREX (Mayo Atlantic Renewable Energy Export)	MAREX is a storage and transmission project to deliver 6TWhr of clean, competitive, dispatchable electricity from Ireland to UK for 31st March 2017	2017	Organic Power Ltd.	Non-TYNDP
BEMIP elec	E97	EE	Muuga Hydroelectric Pumped Storage Power Plant	HPSPP installed capacity is 500 MW. HPSPP use seawater. Maximum volumetric flow rate by power generation and in the pumping mode is 120 m3/s.	2020	OÜ Energiasalv	Non-TYNDP
WE elec	E131	ES/UK	Galicia Iberian Renewable Energy Export (GIBREX)	The concept scheme is a combination storage (Spain) and HVDC transmission system from Galicia in Spain to UK. The location proposed for the conceptual 25GWhr, 2GW capacity sea water PHES has the potential to provide a large scale storage in North West Spain (adjacent to concentrated wind development) to accept Spanish renewable solar and wind generated electricity for dispatch export to UK, via a 600kV HVDC cable to Plymouth UK of at least 10TWhr/yr.	2020	Organic Power Ltd. Company Number Ireland 406133	Non-TYNDP
NSOG	E151	IE	Project CAES-Larne	Phase 1 grid connection at 110kV or 275kV; capacity (net annual generation) initially up to 650GWh, subsequent phases to provide over 2TWh in line with Irish Sea and N Atlantic offshore wind build-out.	2030	Gaelectric Energy Storage Ltd	Non-TYNDP
WE elec	E284	DE	Compressed Air Energy Storage in Harsefeld	An electricity storage facility in an underground geological site. The project will apply on an innovative technology consisting in partially adiabatic compression of air and heat storage. The project's capacity is envisaged at 100 MW generation allowing a net annual capacity generation of at least 130 GWh.	2018/2019	Storengy	Non-TYNDP
WE elec	E183	IT	TuNur	Power generation will be a 2GW CSP tower plant in Southern Tunisia with storage, A 2GW HVDC submarine cable will connect Tunisia with continental Italy; Will supply the European market with approx. 9.5 TWh/y of baseload power.	2020	TuNur Limited	Non-TYNDP
WE elec	E184	IT		Installation of about 250 MW of Innovative Batteries on critical 150 kV transmission network in South Italy		Terna	Storage
CEE elec	E171	IT		Storage projects in Southern Italy		Terna	Non-TYNDP