White book on grid-connected storage

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Content

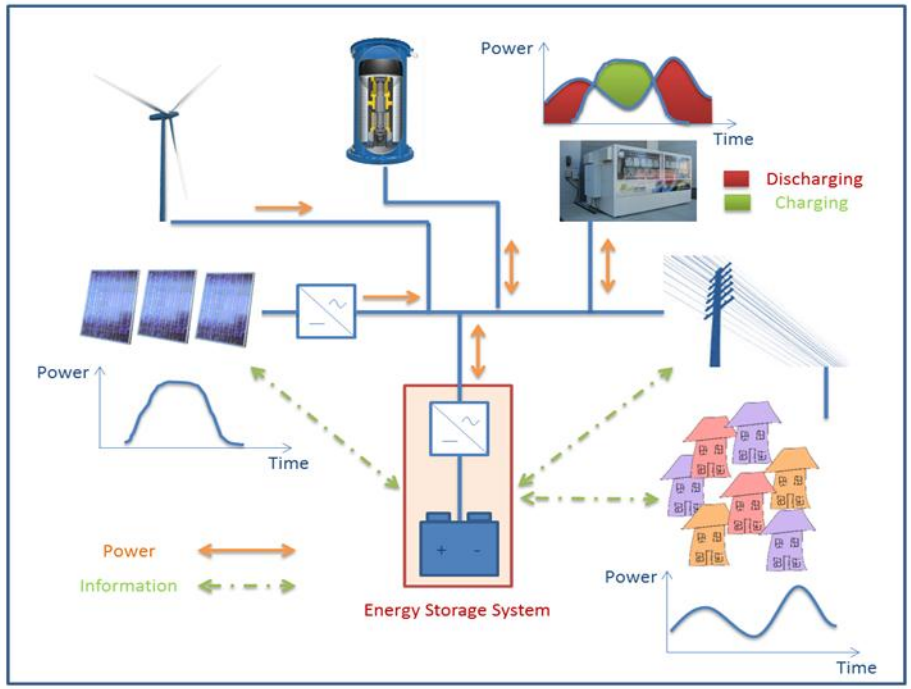
- The DERlab approach to grid-connected storage
- Elaboration process of the white book
- Overview of the different sections
- Follow-up actions

Grid-connected storage: the DERlab approach

- Increased awareness of the need for storage in electricity networks: storage systems can act both as load and as power supply

⇒ Very high potential for grid management and operation!

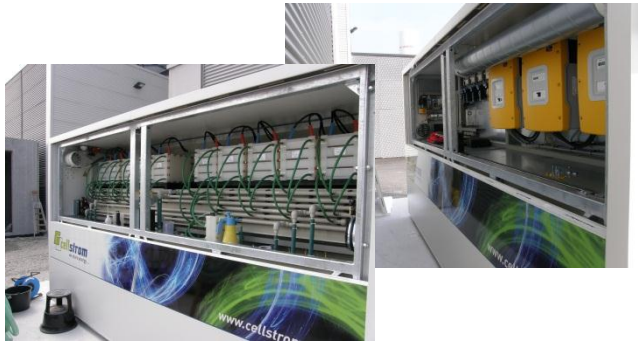
- Several studies about applications of storage in grids, demonstration projects



BUT…

It is a very complex issue:

- ✓ Lots of possible applications
- ✓ Location-dependent
- ✓ Different technologies
  - Batteries
  - Compressed air
  - Pumped hydro
  - …



Grid-connected storage: the DERlab approach

Studies generally take the “grid point of view”
But as seen from the “storage point of view”,
the storage solicitation is similar for many applications

Value Chain		Application	Description
Generation & System-Level Applications	1	Wholesale Energy Services	Utility-scale storage systems for bidding into energy, capacity and ancillary services markets[1]
	2	Renewables Integration	Utility-scale storage providing renewables time shifting, load and ancillary services for grid integration
•	3	Stationary Storage for T&D Support	Systems for T&D system support, improving T&D system utilization factor, and T&D capital deferral
	4	Transportable Storage for T&D Support	Transportable storage systems for T&D system support and T&D deferral at multiple sites as needed
T&D System Applications	5	Distributed Energy Storage Systems	Centrally managed modular systems providing increased customer reliability, grid T&D support and potentially ancillary services
	6	ESCO Aggregated Systems	Residential-customer-sited storage aggregated and centrally managed to provide distribution system benefits
	7	C&I Power Quality and Reliability	Systems to provide power quality and reliability to commercial and industrial customers
•	8	C&I Energy Management	Systems to reduce TOU energy charges and demand charges for C&I customers
	9	Home Energy Management	Systems to shift retail load to reduce TOU energy and demand charges
End-User Applications	10	Home Backup	Systems for backup power for home offices with high reliability value

T&D = Transmission and Distribution; C&I = Commercial and Industrial; ESCO = Energy Services Company; TOU = Time of Use

EPRI

Category 1 — Electric Supply
1. Electric Energy Time-shift
2. Electric Supply Capacity
Category 2 — Ancillary Services
3. Load Following
4. Area Regulation
5. Electric Supply Reserve Capacity
6. Voltage Support
Category 3 — Grid System
7. Transmission Support
8. Transmission Congestion Relief
9. Transmission & Distribution (T&D) Upgrade Deferral
10. Substation On-site Power
Category 4 — End User/Utility Customer
11. Time-of-use (TOU) Energy Cost Management
12. Demand Charge Management
13. Electric Service Reliability
14. Electric Service Power Quality
Category 5 — Renewables Integration
15. Renewables Energy Time-shift
16. Renewables Capacity Firming
17. Wind Generation Grid Integration

SANDIA

Missing information:

- Requirements for storage
- Procedures for selecting the best technology / system, sizing…

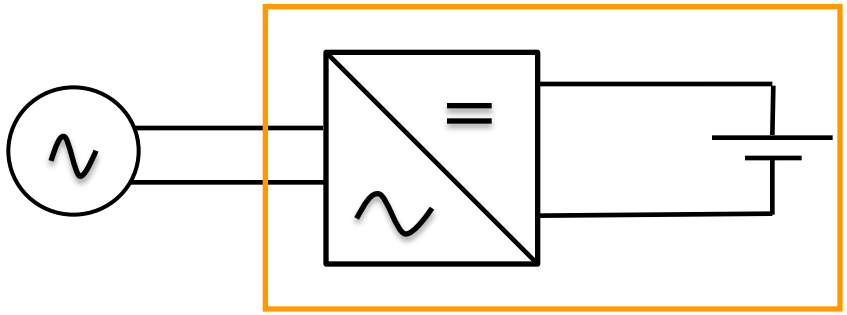
… Standards are needed!

⇒ contribution of DERlab through a **white book**

Scope of the white book

"Our definition" of a Grid-Connected Storage System

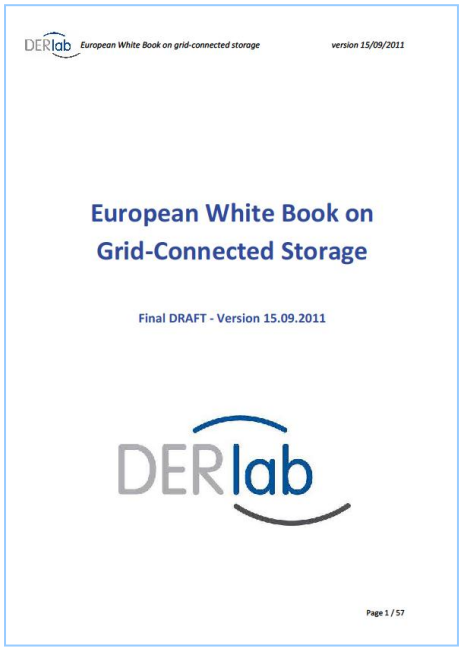
- Bidirectional device
- AC output (storage + converter if needed)
- Connection to the grid is permanent or not (EV)
- Controllable device
- Able to communicate



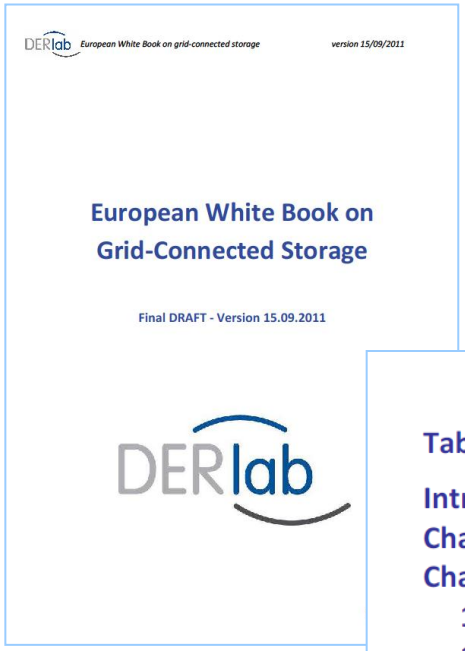
Limits for our study: connected to the distribution network (max. 35kV and 20MVA)

Elaboration process

- Setup of a DERlab working group
- Agreement on approach, scope/limits, contents of the white book
- Organization of workshops
  - Prague, June 2009 (CIRED conference)
  - Berlin, November 2009 (IRES conference)
  - Berlin, November 2010 (IRES conference)
- Aim of these workshops
  - Presentation and discussion of our approach with industrials, network operators, research institutes…
  - Presentation and discussion of the draft white book
- Main authors:
  - E. Lemaire and N. Martin (CEA-INES, FR)
  - P. Nørgård (Risø DTU, DK)
  - E. de Jong, R. de Graaf and J. Groenewegen (KEMA, NL)
  - E. Kolentini (ICCS-NTUA, GR)
  - S. Tselepis (CRES, GR)



Contents of the white book


DERlab European White Book on grid-connected storage version 15/09/2011

European White Book on
Grid-Connected Storage

Final DRAFT - Version 15.09.2011

DERlab

Table of Contents

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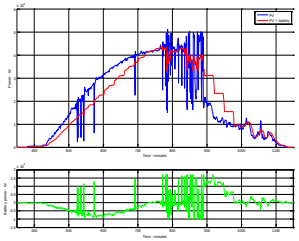
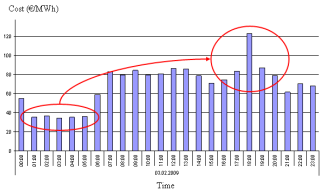
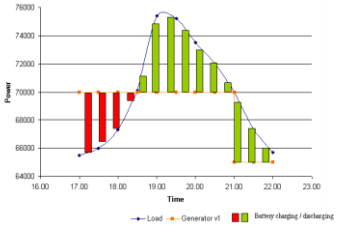
Ch.1 – Definition of application categories

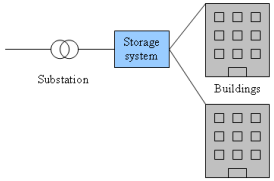
First step in the white book process: to clarify the different system configurations where a storage system could have a strong added value.

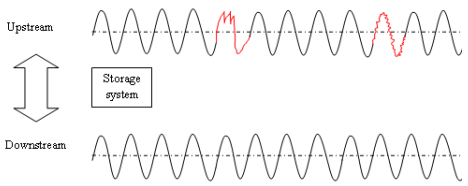
- Analysis of storage applications in grids
- Definition of three generic applications, by analyzing similarities in the storage solicitation

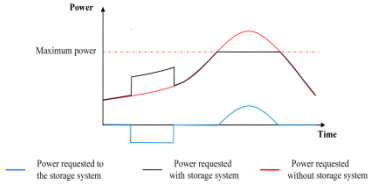












Applications clustering / Methodology

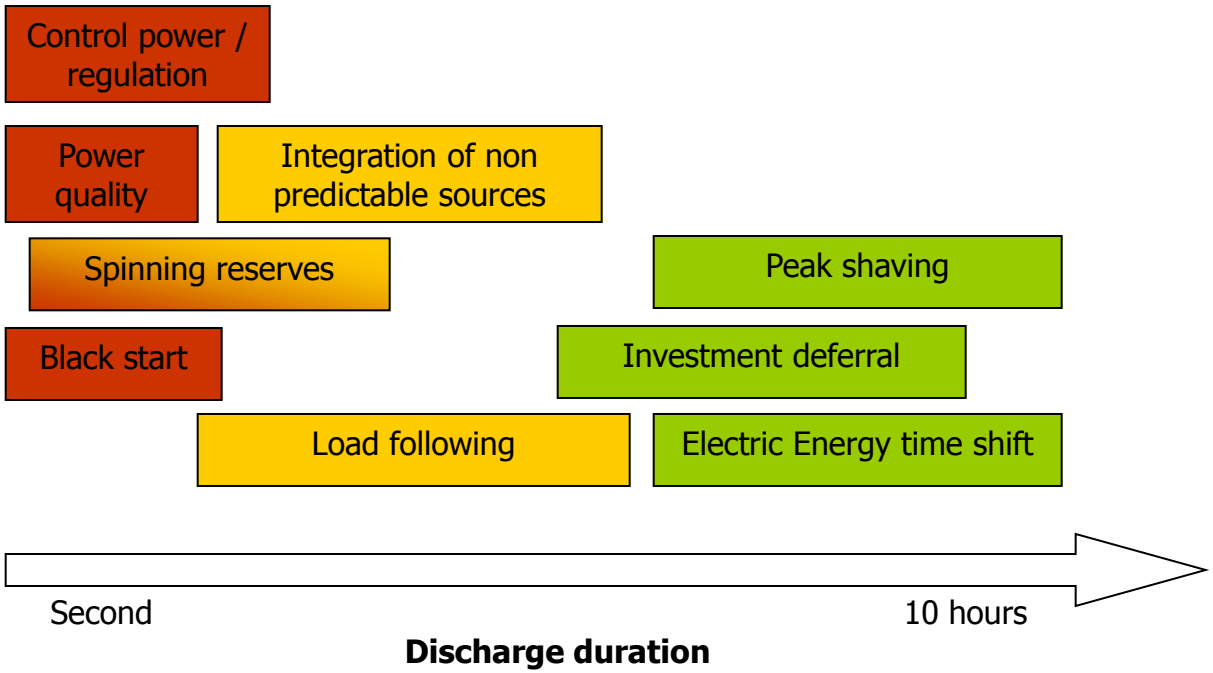
"Grid point of view"

- location on the grid (e.g. end-user, distribution network…).
- amount of energy or power required (storage size)
- kind of service requested (energy, grid support…)
- added value to the grid

"Storage point of view" ⇨ **Solicitation of the storage**

Applications clustering / Methodology

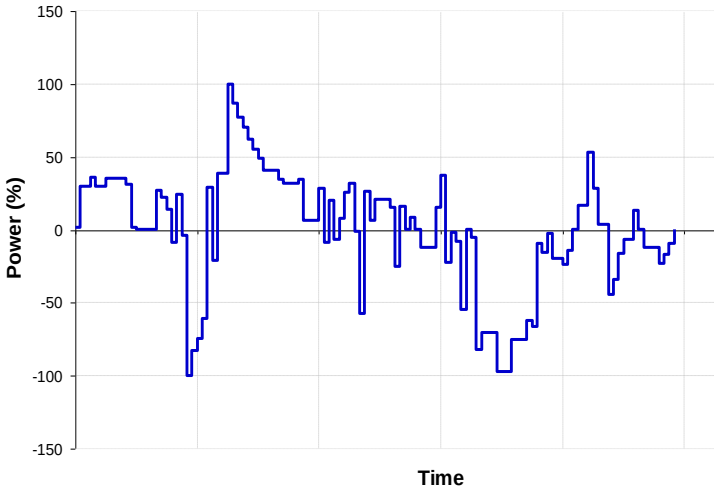
First criterion: discharge duration

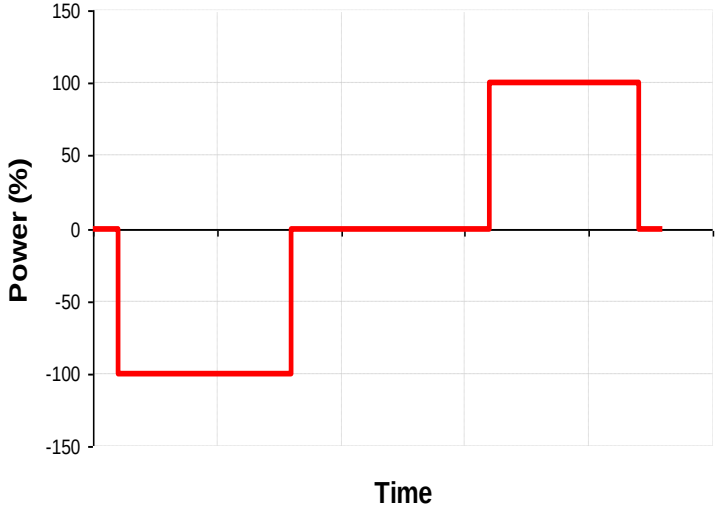


- Need (or not) of short response time (unscheduled discharge)
- High power or high energy storage systems abilities

Applications clustering / Methodology

Second criterion: power profile variability

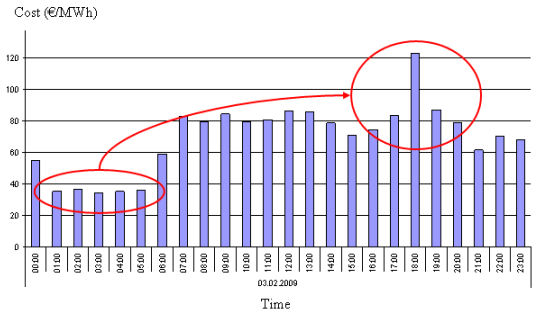


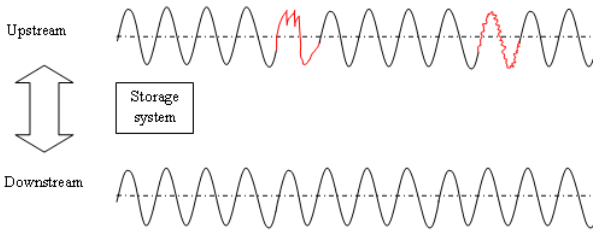


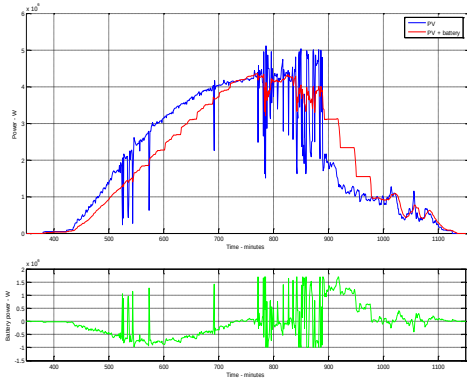
- Fast commutation between charge and discharge modes?

The three application categories

1. **Time shift applications - ENERGY**
   a storage system is used to store energy in order to be discharged later (generally several hours later).
2. **Power balancing - POWER**
   a storage system is used to smooth production/consumption. This involves both energy and power ability and fast changes between both charge/discharge and discharge/charge.
3. **Power quality support - FAST**
   a storage system is used to provide pulse power for ancillary grid services depending on grid conditions.







Ch.2 – Characterization of categories
Ch.3 – Measurements

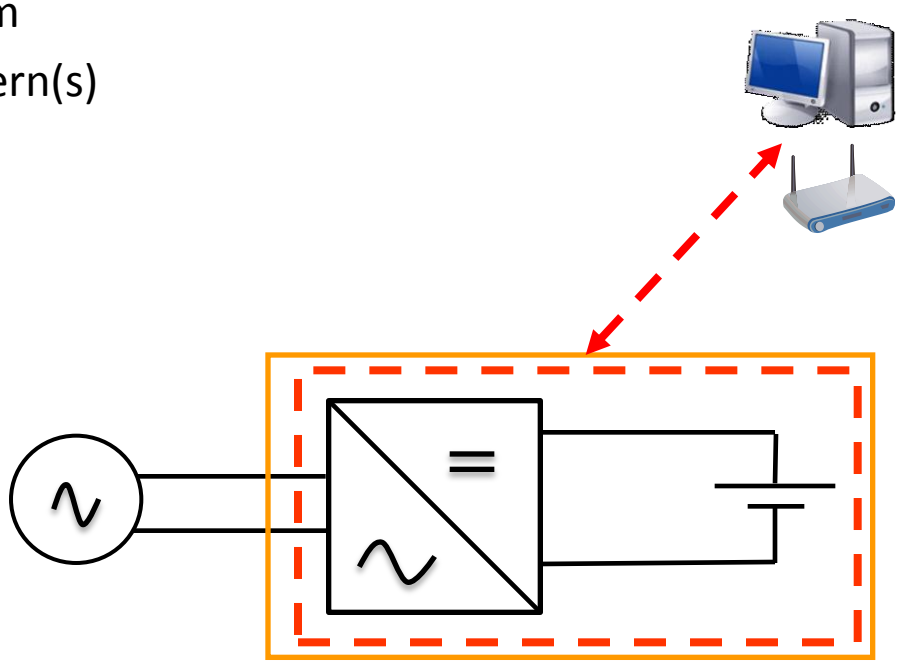
For each of the 3 applications:

- What are the important criteria for the application?
- Propose methods to measure them
- Propose representative cycle pattern(s)

Most important criteria:

- Response time
- Power rating
- Energy rating
- Energy efficiency

  … of the **SYSTEM**



Ch.2 – Characterization of categories
Ch.3 – Measurements

What else to know?

- Footprint, dimensions, weight
- Energy density (Wh/l), specific energy (Wh/kg) of the system
- Temperature dependency

- Calendar life vs cycle life
- Dynamic Performance

- Safety (Operational safety / Operator safety / EMC)
- Short-circuit behavior (Grid side & Internal (safety))
- Transportability

- Controls
- Communications – internal and external

Ch.2 – Characterization of categories
Ch.3 – Measurements

Important conclusions

- System level tests needed
- Interplay between components is complex
  - Inverter properties
  - Storage technology properties
  - Communication
- The combination makes the system!

- Test procedures are application/category dependent:
  - Measurement method can differ
  - Different importance / weight of the criteria

Ch.4 – Economic aspects

For each case:

- Application Overview
- Technical Considerations
- Application Synergies
- Benefit : description and estimate

Main conclusions

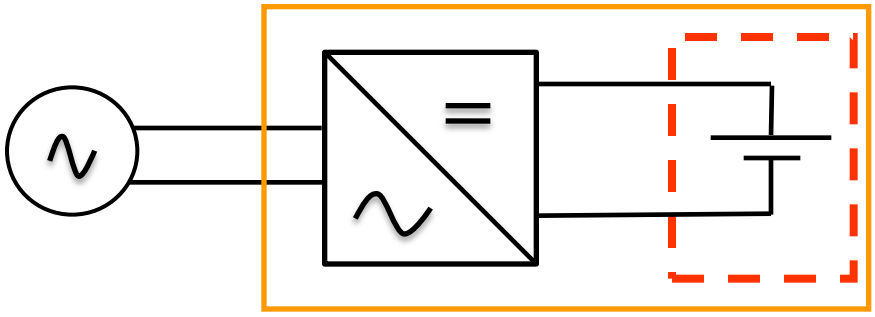
- Importance of the storage integration within a consistent commercial framework.
- A given storage system should be used for several applications (as seen from the grid), so the benefit is multiple.
- Present arrangements and mechanisms for pricing of distribution services do not treat DG and storage adequately and systematically.
- Technical and commercial arrangements dictate the accessibility of networks: rules are needed for both technical and commercial issues.

Ch.5 – Standards

Different types of existing standards:

• Testing methods for **batteries**

- IEC 60896: lead-acid batteries testing for stationary applications
- IEC 60254: lead-acid batteries testing for “Small vehicle” applications
- IEC 61427: lead-acid and nickel based batteries for Stand alone PV applications
- EN 50342: lead-acid starter batteries



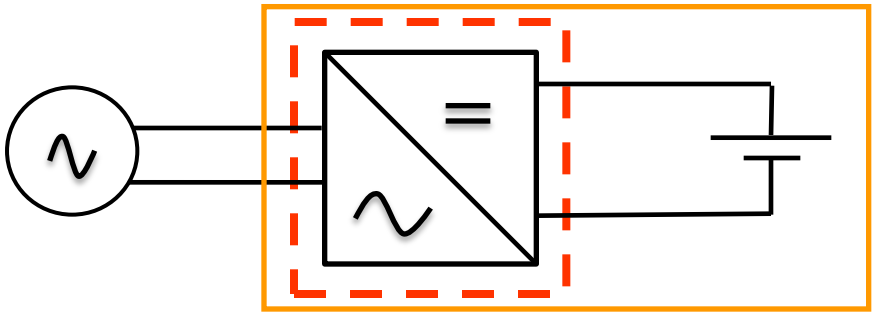
Ch.5 – Standards

Different types of existing standards :

- Testing methods for **batteries**

- Testing methods for **power conversion / connection to the grid**

- IEEE 1547: not specific to storage ; general guidelines for interconnection of DG to the grid and DG interconnection testing.
- IEC 61727: PV connection to the grid (close to IEEE 1547).
- IEC 61687: methods for measuring power conversion efficiency.



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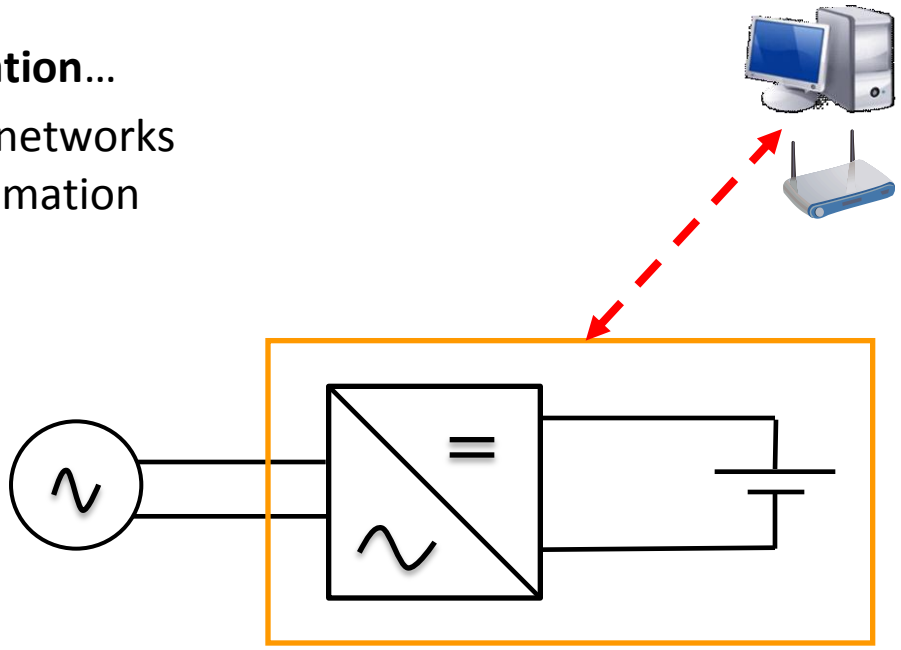
Different types of existing standards:

- Testing methods for **batteries**
- Testing methods for **power conversion / connection to the grid**

- Other aspects: **safety, communication**…
- IEC 61850-7-420: communication networks and systems for power utility automation
- EN 50272: safety requirements for battery installations



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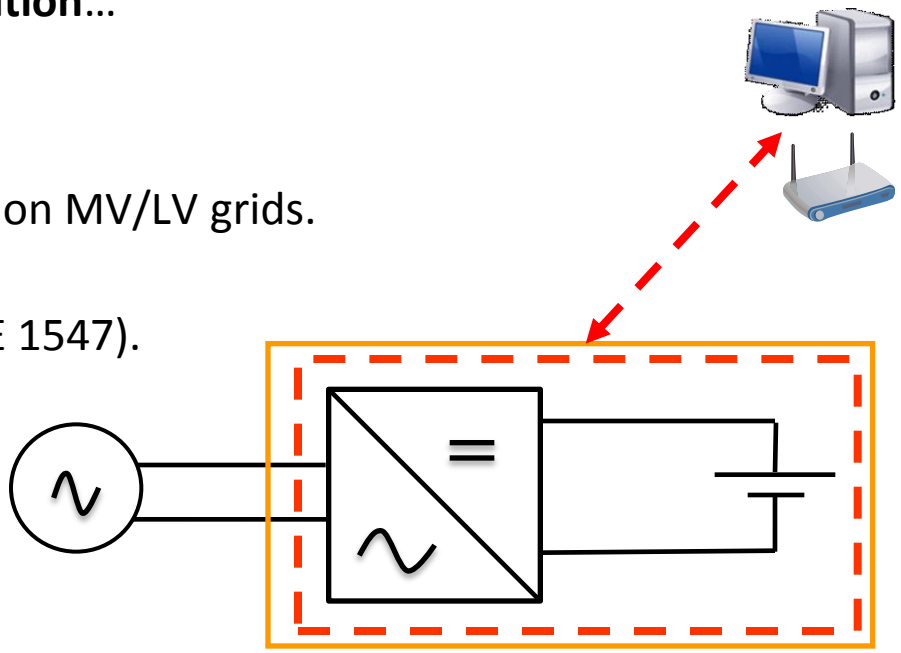
- **Current efforts:**

- IEC-TC8X, WG3: connection of DG on MV/LV grids.
- Improvement and extension of already existing standards (eg IEEE 1547).
- IEC TC 57: power systems control including EMS, SCADA



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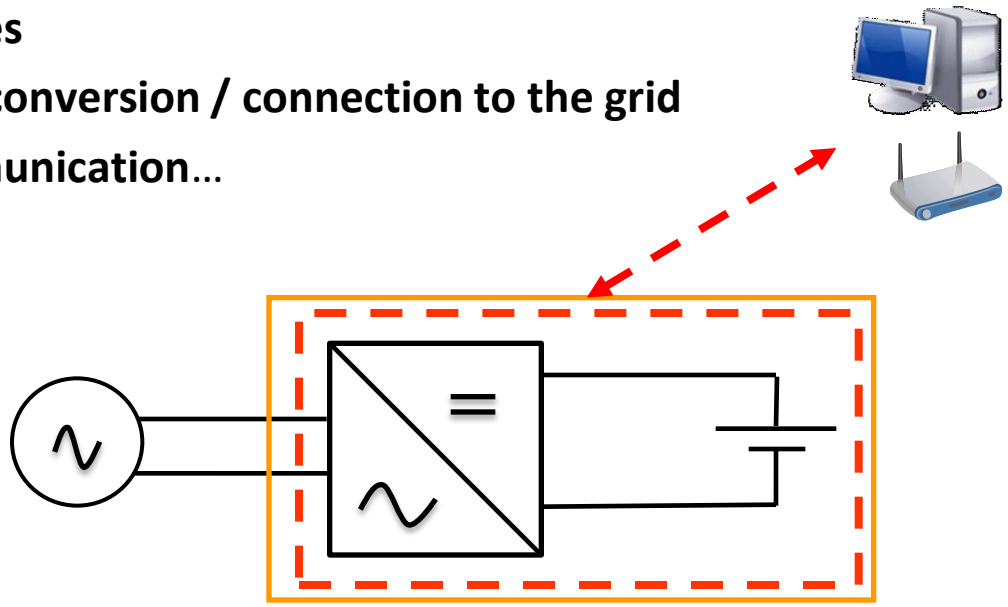


- **Conclusion**

- Absence of a harmonized interconnection standard in Europe (storage systems and other DG): technical issues (plugs…), economical (metering), administrative (grid codes).

Follow-up actions

DERRI project (coordinated by RSE, Italy)

- Consortium of Research Infrastructures
- Objective: supporting the sustainable integration of RES and DER by developing common requirements, standards and quality criteria, as well as proposing test and certification procedures
- Main focus is on **Transnational Access:** opportunity offered to Researchers Groups of using free-of-charge selected experimental installations for making tests in the Distributed Energy Resources field
- Networking Activities & Joint Research Activities: to facilitate the access at the research infrastructures and to improve their availability and capability

- Joint Research Activity on Grid-Connected Storage

⇒ Clarify the performance criteria and the associated characterization methods for DER components to be connected to smart electricity grids, focusing on storage systems and large-scale RES inverters

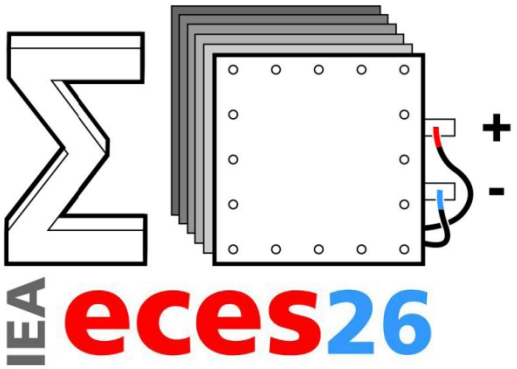
More information: www.der-ri.net

Follow-up actions

IEA ECES – Annex 26

ECES Program
Energy Conservation through Energy Storage

Newly created Annex 26
»**Future Electric Energy Storage Demand**«



- Main objective: develop a method / approach to calculate the **regional energy balancing demand** and to derive **regional storage demand** rasterizing the area and taking into account that there are competitive technical solutions.
- Two other important aspects:
  - Overview on the different **technical, economical and legal framework requirements** in the different countries.
  - **Typical operation modes for energy storages** and derived from this typical charge/discharge curves, needed for future standardizations and test procedures.

Contact: Dr. Christian Doetsch (FhG UMSICHT)
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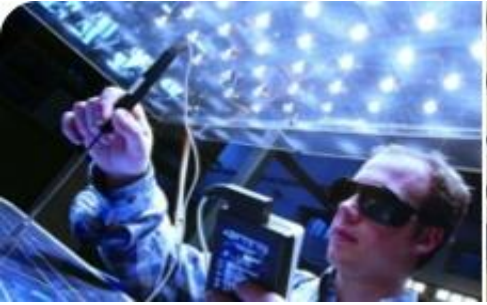
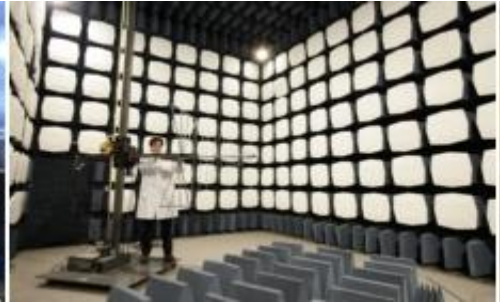

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