IEA Energy Conservation through Energy Storage Programme

- since 1978
- Thermal or Electrical Energy Storage Technologies
- Mission
  “To facilitate an integral research, development, implementation and integration of energy storage technologies to optimize energy efficiency in any kind of energy system and to enable the increasing use of renewable energy instead of fossil fuels.”
- 18 Participating Countries
- Chair: Halime Paksoy, Cukurova University, Turkey
Energy Storage Matching Supply and Demand

Alternatives
- Solar
- Natural heat and cold
- Waste heat
- Wind
- Hydro

Energy Storage
- Thermal
- Electrical

Users
- Buildings and DHC
- Industry
- Agriculture
- Transportation
- CSP
- Others…
Participating Countries

[Images of flags from various countries]
IEA Committee on Energy Research and Technology
EXPERTS’ GROUP ON R&D PRIORITY-SETTING AND EVALUATION
The Role of Storage in Energy System Flexibility
Berlin (Germany), 22\textsuperscript{nd} October 2014

»Future Electric Energy Storage Demand«
- Results from the IEA eces26 project

Dr. Christian Doetsch (OA eces26)
Fraunhofer UMSICHT

Supported by:

Federal Ministry of Economics and Technology
on the basis of a decision by the German Bundestag
General approach

What is the aim of a project called „Future electric energy storage demand“?

The most expected answer is:

„In 20xx (year) the energy storage demand for yy (country) is about zz GW“
General approach

What is the aim of a project called „Future electric energy storage demand“?

The most expected answer is:

„In 20xx (year) the energy storage demand for yy (country) is about zz GW“

But this is wrong!
Example: Travelling

If you want to go from A to B you can derive a demand of using your car for (e.g.) 2 hrs for this way....
Example: Travelling

If you want to go from A to B you can derive a demand of using your car for (e.g.) 2 hrs for this way….

But this is not the general demand. This is only ONE technical solution. And it is only valid for a single special case.

The real demand is to **travel** from A to B (incl. distance, time, comfort etc.).
Example: Travelling

And there are more opportunities then only one …. 

Your own car
Example: Travelling

And there more opportunities then only one ....

Aircraft
Your own car
Rental car, car sharing
Taxi cab, hitchhiking
Motor cycle, bicycle
Walk by feet
Example: Travelling

And there more opportunities then only one ….

Decision will be made by

► (technical) feasibility e.g. time to travel

► economics e.g. reasonable cost

► (legal) framework e.g. what is allowed by your company
1st Conclusion
Technical Storage Demand

► There is NO (technical) electric energy storage DEMAND!
  (but mobile application)

► There is only an electric energy BALANCING demand which opens a real
  MARKET for different balancing technologies
  (storage, DSM, curtailment etc.) which compete which each other.

► This market is mainly influenced by technical feasibility, economics, and
  legal framework

► Energy storages will be part of the solution – the share will depend on
  economic figures and climate aims.

► Watch the business case!
Energy Balancing Options vs. Energy Storage

Temporary Energy Balancing
- Virtual power plant - OFF
- Demand side management - ON

Permanent Energy Balancing
- Generation curtailment
- Power to X (e.g. P2G, P2H)
- Ex-/Import – grid enhancement

Energy Balancing Options
- Surplus of Energy
- Alternating Surplus/Lack of Energy
- Lack of Energy

Energy Storage

Additive generation (e.g. gas turbine)
# Energy Balancing Options: Pros and Cons

<table>
<thead>
<tr>
<th>Highly flexible, multiple services, usage of unused energy</th>
<th>Energy Storage</th>
<th>Mostly high CAPEX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inexpensive if existing power plant could be “virtualized”</td>
<td>Virtual power plant</td>
<td>Additional thermal storage needed, limited potential due to heat demand</td>
</tr>
<tr>
<td>Probably inexpensive</td>
<td>Demand side management</td>
<td>Additional thermal storage needed, limited potential due to heat demand</td>
</tr>
<tr>
<td>Easy and cheap to realize</td>
<td>Generation curtailment</td>
<td>Wasting energy, probably higher CO2-emissions</td>
</tr>
<tr>
<td>Permanent balancing option, inexpensive (P2H), easy to manage</td>
<td>Power to X (e.g. P2G, P2H)</td>
<td>Expensive (P2G), need for high ramping rates, less operating hours</td>
</tr>
<tr>
<td>Highly flexible, multiple services/applications</td>
<td>Additive generation (e.g. gas turbine)</td>
<td>Additive CO2 production; less operating hours -&gt; business case?</td>
</tr>
<tr>
<td>Highly flexible</td>
<td>Ex-/Import – grid enhancement</td>
<td>NIMBY; probably only exporting balancing problems</td>
</tr>
</tbody>
</table>
2\textsuperscript{nd} Conclusion: “How should energy balancing demand be compensated?”

- Cheap solutions (curtailment, additive generation) are less efficient (CO2 emissions) and only reasonable for short periods.

- Inexpensive solutions (DSM, VPP) are reasonable, but often not easy to realize and have a limited potential.

- “Leaving” the electric market (power to x) is reasonable for a permanent surplus but not for balancing short term imbalances.

- Export/Import is limited due to NIMBY, transformer capacity and willingness of neighbor countries to solve German balancing problems.

- Energy storage is the only, nearly unlimited potential with less NIMBY effect, but CAPEX are too high => cost degression is needed.
3rd Conclusion:
“How should energy balancing demand be compensated?”

To get an overall efficient, environmental friendly and economic solution on an energy balancing market there must be….

► a fair access to the market for all technical solutions and stakeholders

► a transparent market with public accessible price systems

► market rules which enables business cases for the best fitting solutions

And probably individual subsidies for new, promising technologies to reach maturity and to come to the market
Preface

The main objective of this task is to develop a method or 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.

Additionally there are two important aspects. On the one hand an overview about the different technical and economical and legal framework requirements in the different countries.

Case Studies: Running projects, planned projects and future projects of stationary energy storage systems.

And on the other hand typical operation modes for energy storages and derived from this typical charge/discharge curves, needed for future standardizations.
**ECES 26 »Future Electric Energy Balancing/ Storage Demand«**

| WP 0   | Project organization (Operating agent) | Project Leader  
|        |                                       | Dr. Christian Doetsch  
|        |                                       | Fraunhofer UMSICHT |
| WP 1   | Technical and economic framework requirements for electric energy storage systems | Leader work package 1  
|        |                                       | Dr. Bert Droste-Franke  
|        |                                       | European Academy |
| WP 2   | Calculation Method to determine spatial demand for electric energy balancing/storage systems | Leader work package 2  
|        |                                       | Dr. Yvonne Scholz  
|        |                                       | DLR - GERMANY |
| WP 3   | Technical Storage Issue:  
|        | Application of electric energy storage | Leader work package 3  
|        |                                       | Dr. Grietus Mulder  
|        |                                       | VITO, Belgium |
| WP 4   | Requirements for test procedures | Leader work package 4  
|        |                                       | Dr. Marion Perrin  
|        |                                       | INES-CEA - France |
ECES 26 »Future Electric Energy Balancing/ Storage Demand«

WP 2 Calculation Method to determine spatial demand for electric energy balancing/storage systems

Some basic conditions/assumptions

- the model bases on Germany as reference
- the model includes different balancing technologies
- the model takes into account that there are positive and negative balancing demands
Why is Germany a good case study?

► Need of energy balancing devices

► In Germany most problems will occur at first

Fig.: Installed electricity generation power in different European countries
Grid Balancing Demand Analysis: Power vs. Yearly Stored Energy

2050 - additional „discharging“ power (annual duration curve)

- Maximum storage, assumption: no export by interconnectors allowed
- Maximum storage, assumption: maximal export by interconnectors possible

Example

Storage → Grid

20 TWh
2 TWh

Time in hours

2050 - additional „charging“ power (annual duration curve)

- Maximum storage, assumption: no import by interconnectors allowed
- Minimum storage, assumption: maximal import by interconnectors possible

Example

Storage ← Grid

132 TWh
27 TWh

Time in hours
Grid Balancing Demand Analysis: Power vs. Yearly Stored Energy

Example:
Grid Balancing Demand 2050
Discharging: 2-10 TWh
Charging: 27-132 TWh

2050 - additional „discharging“ power (annual duration curve)
- Maximum storage, assumption: no export by interconnectors allowed
- Maximum storage, assumption: maximal export by interconnectors possible

2050 - additional „charging“ power (annual duration curve)
- Maximum storage, assumption: no import by interconnectors allowed
- Minimum storage, assumption: maximal import by interconnectors possible

Example
Storage ➔ Grid

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2014-Oct-22, Berlin, IEA BMWI Meeting, Chart 22
Key Figures of Energy Balancing Demand

► There is disparity between positive and negative balancing demand
  - positive balancing demand: lack of electric energy
    (e.g. discharging storage or DSM)
  - negative balancing demand: surplus of electric energy
    (e.g. charging storage or power2heat)

► The annual amount of energy balancing demand is calculated in TWh/a
  - this figures shows if there is a total annual surplus or lack of electric energy
  - from these figures the potential market for energy storage devices could be derived
    (the minimum of both figures, because storage devices must be balanced!)

► The needed capacities (MWh) of storage devices are the result of a hourly based simulation
Allocation of Germany into 6 953 cells

GIS Raster
- raster maps 0.083° x 0.083° approx. 9 x 6 km
- 6,953 cells
- N-S length: 886 km
  W-E width: 636 km
  area: 357 121 km²
- “perfect grid” in each cell
Aggregation of 9536 cells to 146 Energy regions in Germany

Aggregation
- 146 regions in model
- Aggregation according to “density” of local inhabitants and urban characteristics
- First assumption “perfect grid” in each region but not between areas for balancing demand analysis (own illustration)
Modeling

grid

parameters
- degree of intermeshing
- electric circuit length
- load density
- transmission capacity
- switching system

energy system

demand
- load profile
- number
- 9 types of consumer (households, agriculture, commerce/trade/services, industry)

supply

parameters
- installed capacity
- fluctuating RE
- projectable EE
- conventional power stations
- generated electricity
Input Data

Demand

Electricity Generation

Szenarios

**Definition of szenarios based on “Leitstudie 2010”**

**Local** and hourly energy balancing demand

(*per cell and per region)
Detailed Example: Scenario 2050 for energy region 68

- Haltern, Xanten, Lüdenscheid, Grevenbroich, etc.
Total Annual Regional Energy Balancing Demand [TWh/a]
(with infinity storage capacity in the regions !)
(without interconnections between the regions !)
Results

- Based on “Leitstudie 2010”
- Extreme scenario: - No grid between 146 regions
  - unlimited storage capacities
- Permanent (over the year) surplus of electric energy in the north (new lines needed)
- Lack of energy in big cities (power plant are often around)
- Model very sensitive to operation of fossil power plants (putting out of order or building a new fossil power plant)
Sorted annual curve of the Energy Balancing Demand in Germany (perfect grid, no ex-/import assumed)

Surplus approx. 2.5 TWh
Sorted annual Curve of the Energy Balancing Demand in Germany (perfect grid, no ex-/import assumed)

- Surplus: approx. 27.7 TWh
- Lack: approx. 1 TWh
Sorted annual Curve of the Energy Balancing Demand in Germany (perfect grid, no ex-/import assumed)

Surplus approx. 80 TWh

Lack approx. 3.3 TWh
Energy System Modelling –
Example: Future overall Electric Balancing Demand (Germany)

■ Assumptions
- Perfect grid, no interaction with neighbors
- Germany in total, without P2Gas, P2Heat etc.

■ Results
- In 2020 nearly no balancing demand
- In 2030 a storage »market« for 1.0 TWh/a
- In 2050 a storage »market« for 3.3 TWh/a
- Surplus of energy 25 times higher than lack of energy

⇒ Energy utilization for high short generation peaks are needed
Energy System Modelling
Energy Storage / Power2Product / Power2Heat

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2014-Oct-22, Berlin, IEA BMWI Meeting, Chart 40
Energy System Modelling
Energy Storage / Power2Product / Power2Heat

Power-to-Product

Power2Product includes P2G
Energy System Modelling
Energy Storage / Power2Product / Power2Heat

Power-to-Product includes P2G