Session 4: Electrical Storage Technologies

Techno-Economic Issues

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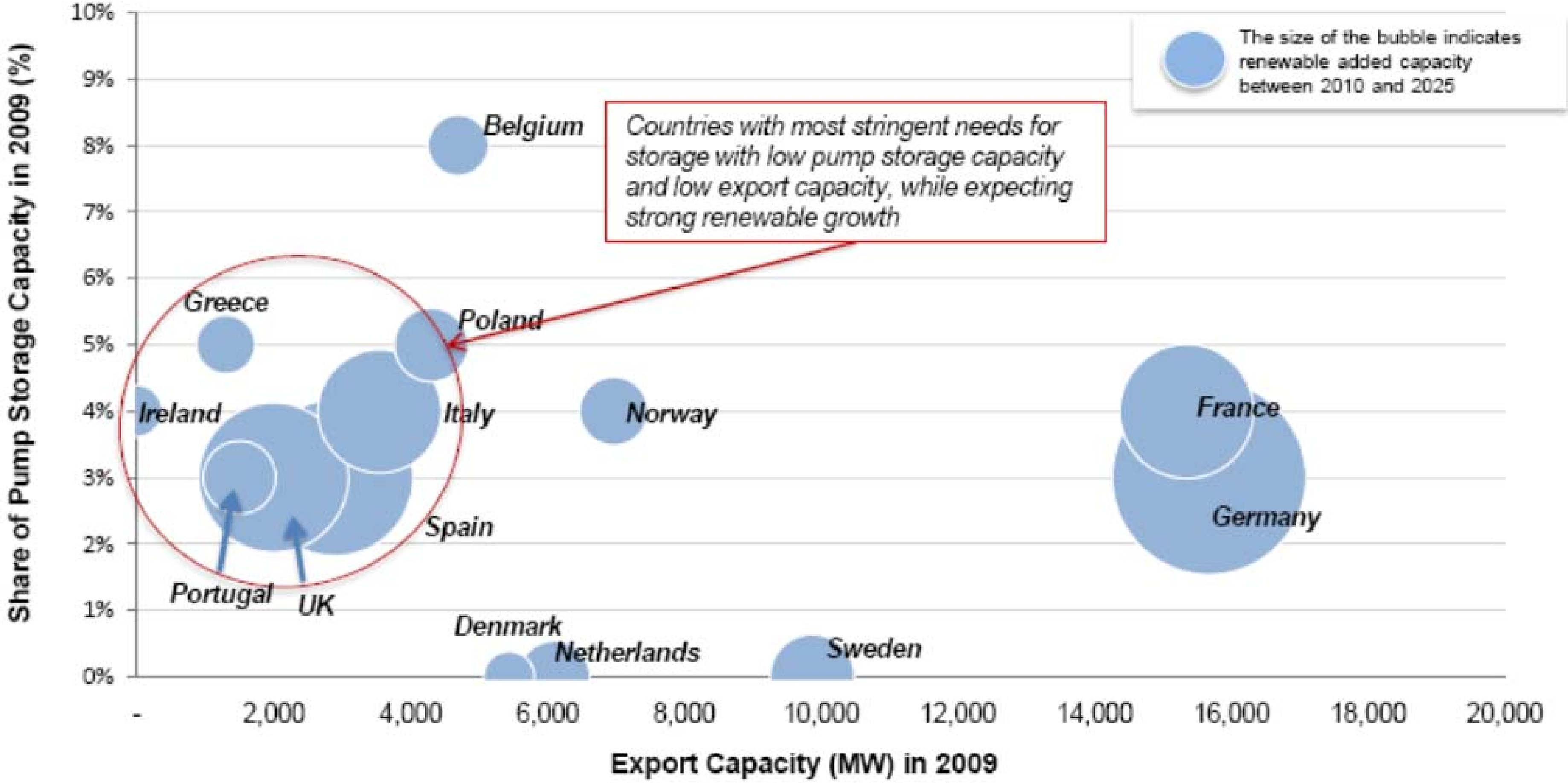
ES in European Smart Grid Applications

- Grid connected ES deployment in Europe has been rather slow.
- Main grid connected storage technology has been pumped hydro built (36 GW) earlier mainly as a peaking plant to compliment nuclear power

- ✓ In the framework of the European Strategic Energy Technology Plan (SET-Plan) implementation, the Energy Storage has been identified as a critical technology for the transition to and operation of a more sustainable and low carbon European energy system
- ✓ European Commission - Research: The Seventh Framework Programme FP7 work aims at promoting the innovations in technology and at system level to support smart network evolution. Supporting technologies includes also energy storages.
- ✓ The EU's 20:20:20 program for 2020 – 20% reduction in GHG emission, 20% of energy provided by renewable sources, and 20% improvement in energy efficiency
  - ➢ Intermittend renewable energy is now fast increasing because of EU renewable power committments
- ➢ <u>More (grid integrated) storage systems will be promoted & needed in EU!</u>

ES in European Smart Grid Applications

Storage needs by country based on low export capacity and low storage capacity while expecting strong renewable growth



Source: Boust, M. Assess the Storage Needs to Meet Europe Renewable Growth. Energy Storage Forum Europe 2010

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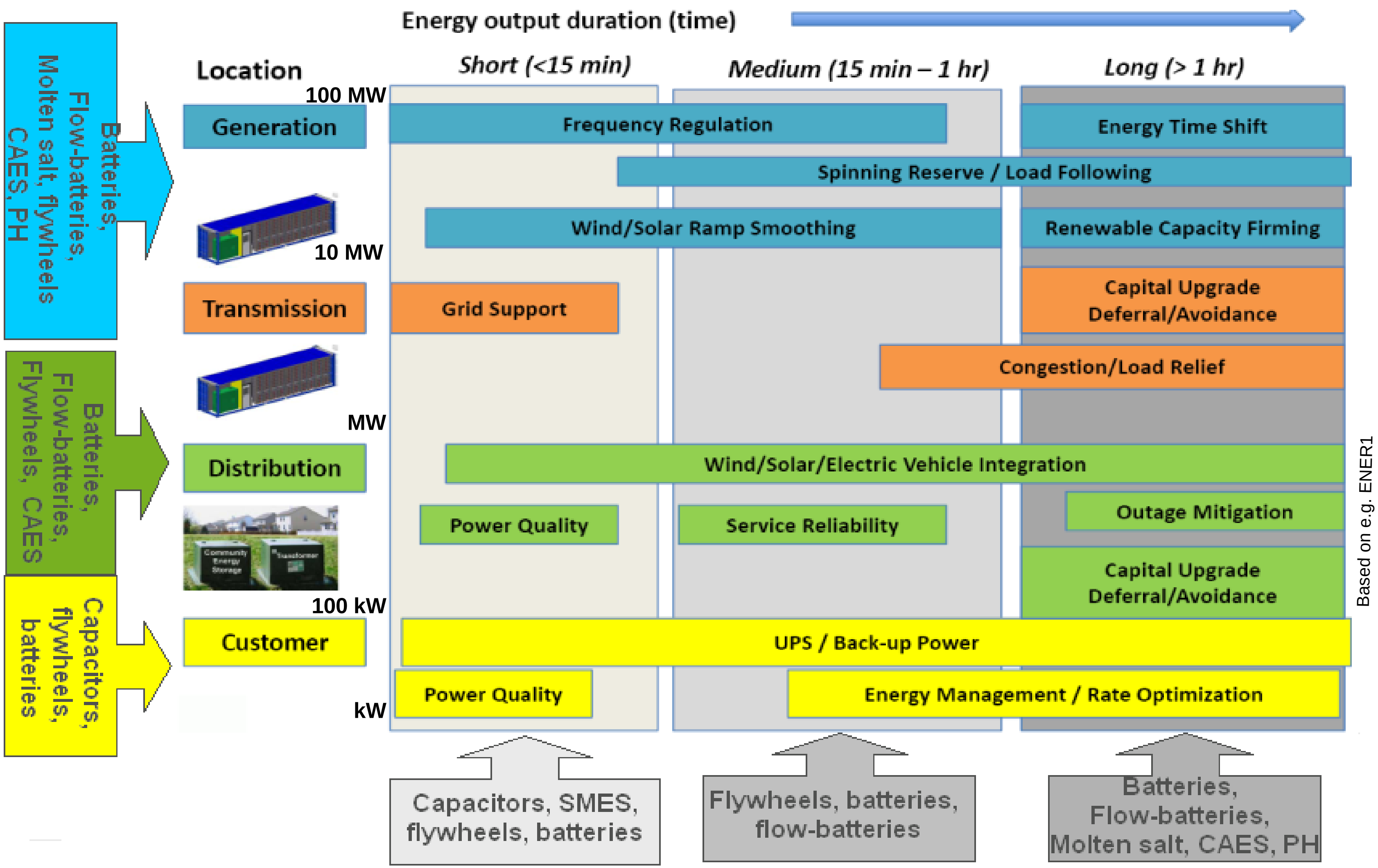
ES in European Smart Grid Applications

Different types of ES cover the needs of the SG application services



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EES Benefits in Smart Grid Applications

- The prerequisite for the use of energy storages is an accurate evaluation of EES benefits

  - Cost and Benefits Dilemma!

    - ✓ What are the real total costs?
    - ✓ How to show all benefits, also non-profit
    - ✓ How to get all stakeholders who get benefits also to share cost = to participate the investment

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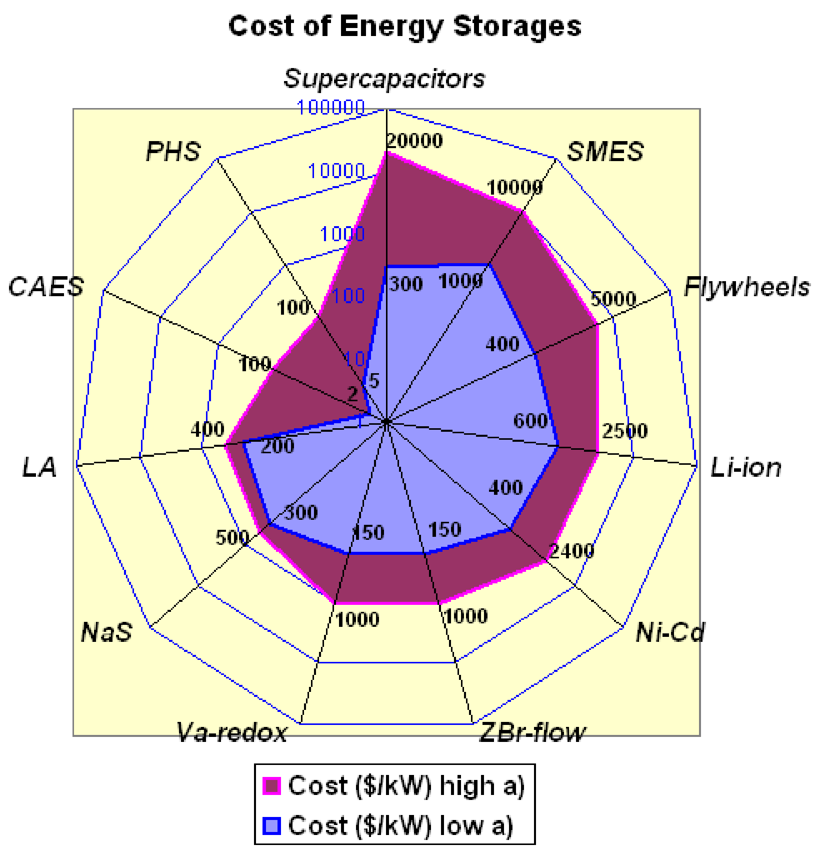
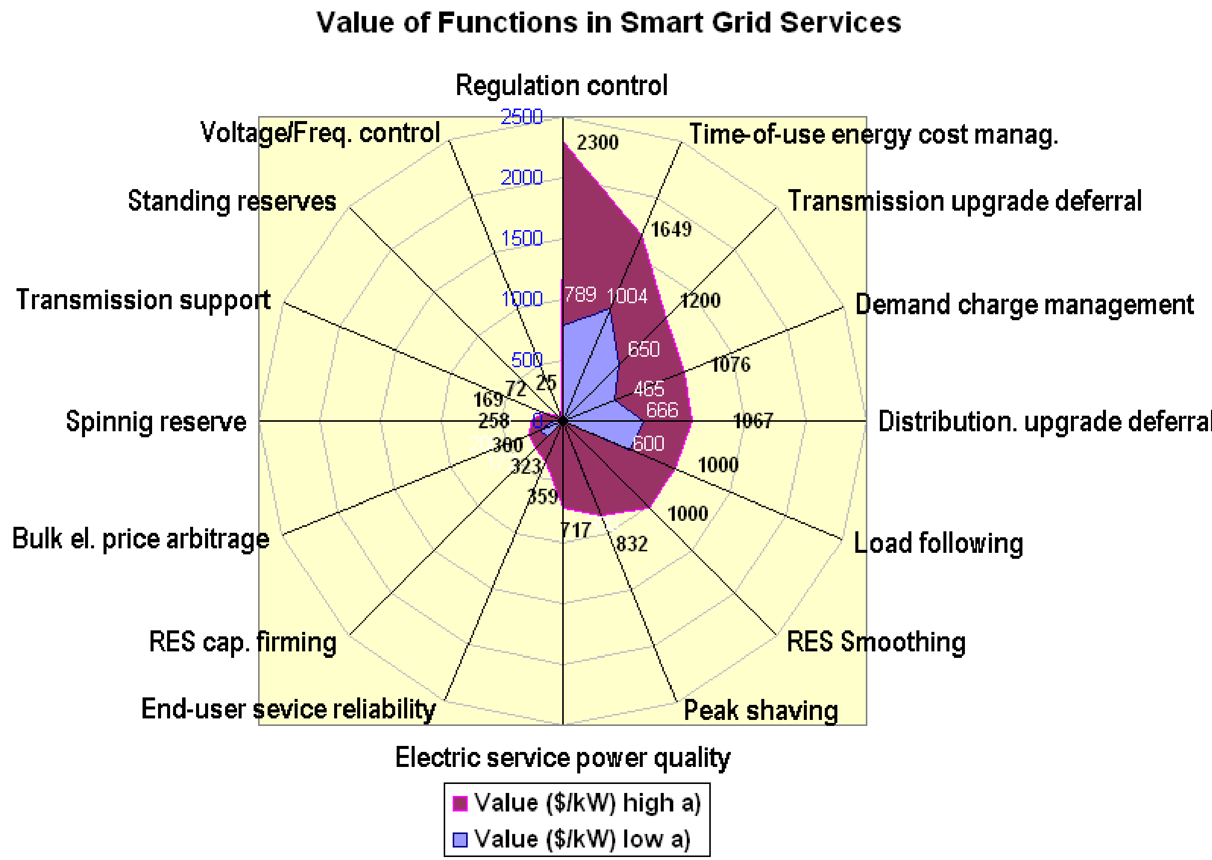
Large Differences in the Available Cost and Value Estimations for ES





a) Data from various sources e.g. Beauding et.al. 2010; Chen et al., 2009; Hadjipaschalis et al., 2009, EERA SG

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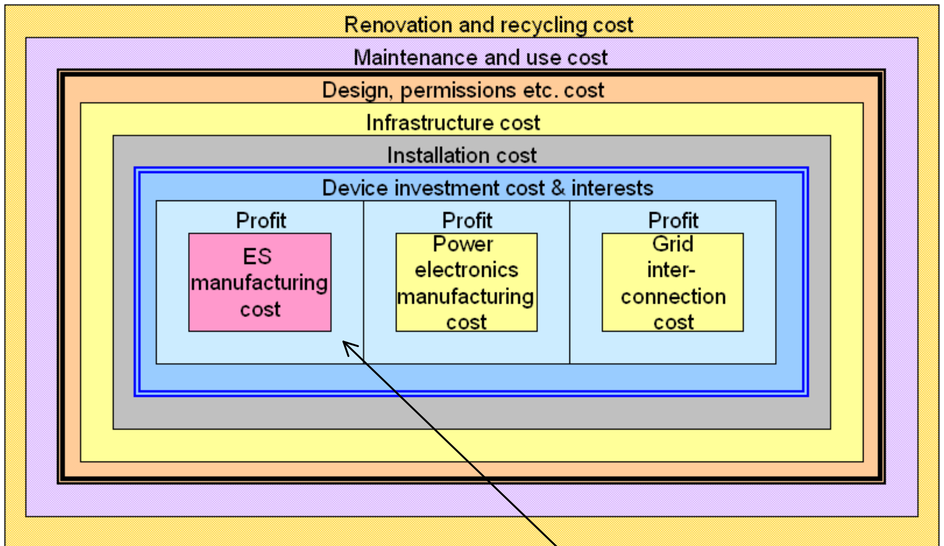
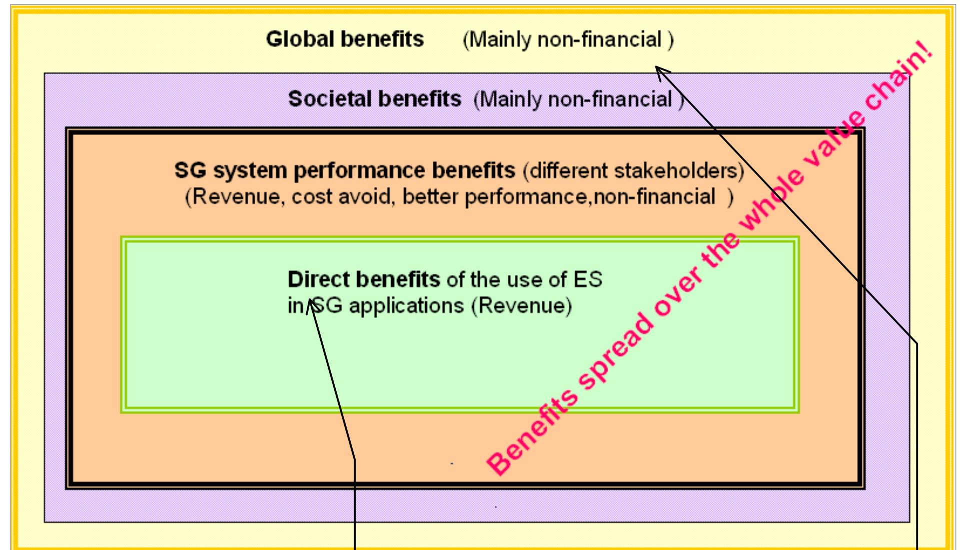
EES system profit = Benefits - Cost

Cost and Benefits are Place and Case Depending

Total cost



Total benefits



- •ES not off-the-self products! (Except sup caps and LAs)
- •Very large variations of cost-estimations
- => Need to have more accurate price knowledge before quotation!

- •Can be estimated if ES system price is known (precisely after offer)
- •Benefit owner (investor) is known
- •Typically seen as the only reason to invest on ESS

- •Can be estimated sometimes
- •Benefit owners are often unclear!
- •Support/subsidies are needed!

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ES in European Smart Grid Applications, Barriers

According to SETIS (the European Commission's Information System for the *SET*-Plan) there are several barriers for Energy Storage implementation in Europe e.g.

- The level of communication & coordination between European actors on the Energy Storage field is quite low;
- Lack of quantified vision on the value of unconventional sources of flexibility that includes storage and on the future flexibility needs in the European electric system;
- Regulation barriers (in particular, lacking rights for TSO / DSO to own or operate the Energy Storage installations);
- Existing renewable feed-in tariffs, reducing the incentives for coupling Energy Storage to Renewables generation;
- Existing grid access tariffs, increasing the cost of Energy Storage operation;
- Lack of visibility of Energy Storage needs on the European level;
- Lack of standardization (storage solutions & interfaces) and harmonization (regulation)

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ES in European Smart Grid Applications
Profit on electricity market with ES systems?

- There is not yet pan-European power market but in the beginning 2011 NorNed cable integrated Central Western Europe and Nordic systems enabling a day-ahead market of 1800 Terawatt hours.
- Nord Pool Spot's is the largest exchange for electrical energy in the world (307 TWh in 2010), offering both day-ahead and intraday markets.
- Elbas is Nord Pool Spot's intraday market for the Nordic region, Germany and Estonia (2.2 TWh in 2010). In this market place, trade continues even up to one hour before the delivery.
- The European supergrid and pan-European electricity market may decrease the need to use energy storages in future (the grid acts as an electricity storage)
- However, there are national subsidies e.g. for renewable production and <u>the tool to keep the benefits of subsidies</u> e.g. low CO_2 emission power production <u>inside the country is an energy storage</u>

ES in European Smart Grid Applications
Profit on electricity market with ES systems?

Today electricity storage facility could make profit in the Nordic power system

1. From buying and selling power on the spot market
2. On the regulating market, which maintain energy supply and demand balance in real time. Demand and intermittent RES supply forecasts are not perfect and the imbalances are handled by the regulating market
3. By selling ancillary services to the transmission system operator (TSO)

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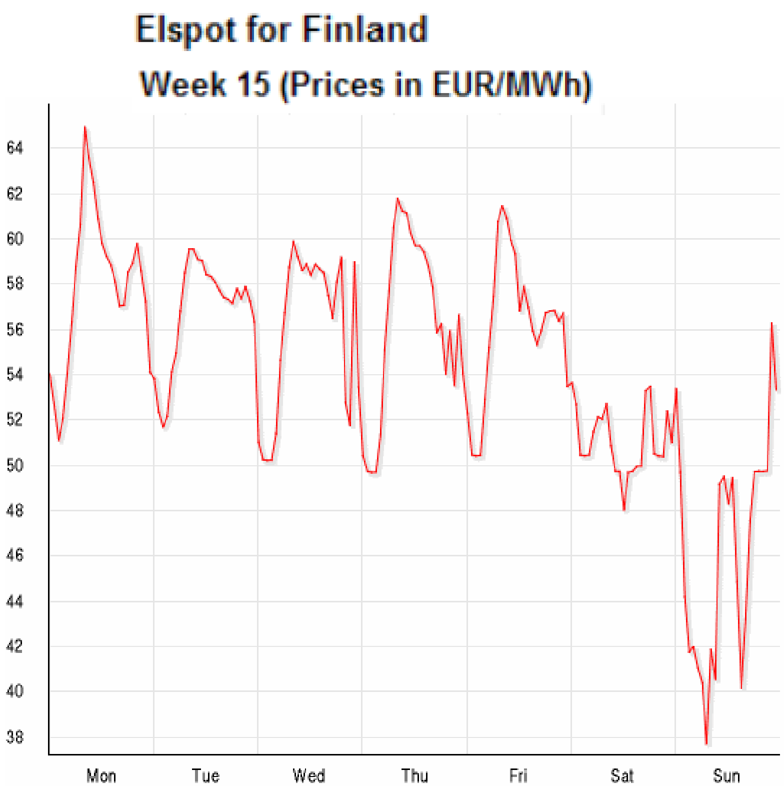
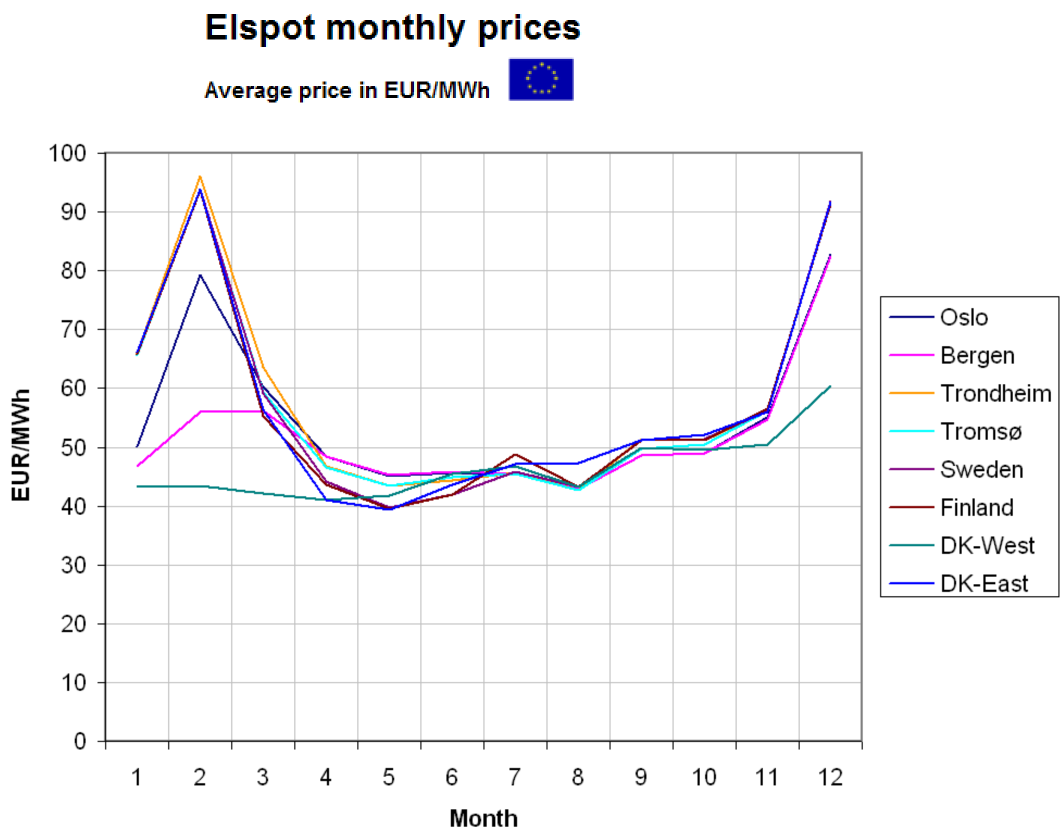
ES in European Smart Grid Applications
Profit from arbitrage on the spot market ?

- Elspot market prices varies according to the time of a day, a weekday and seasonally





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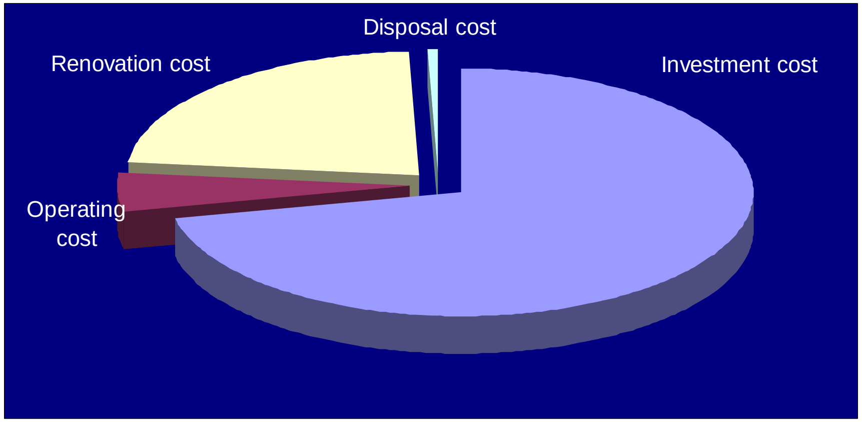
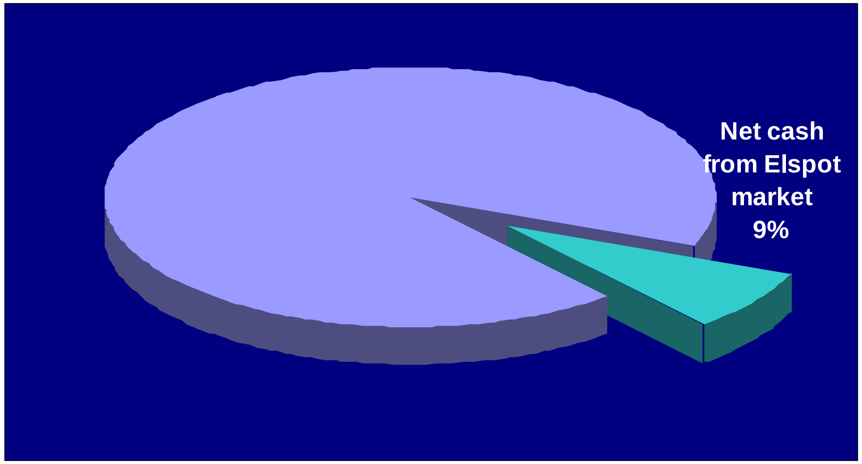
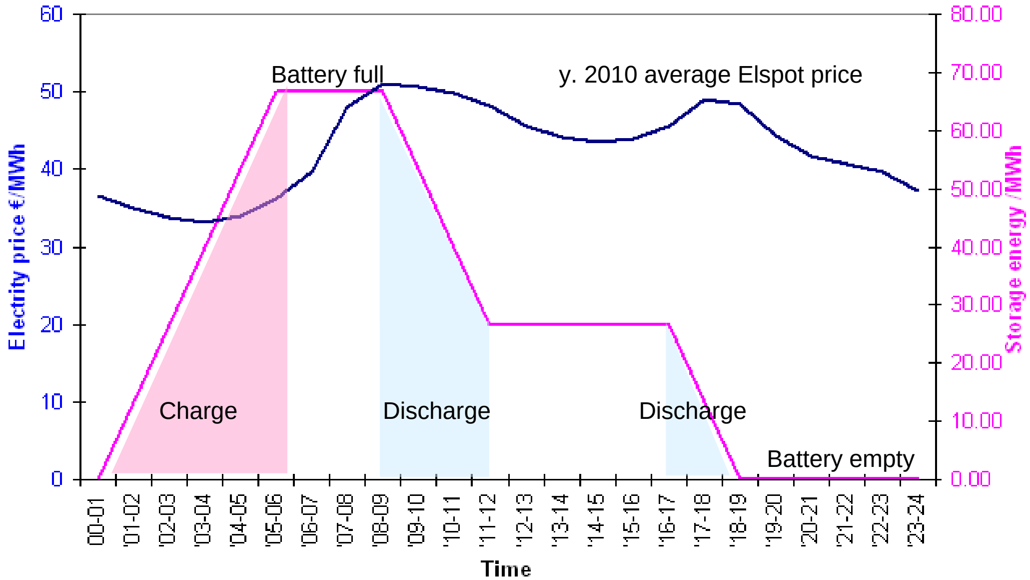
ES in European Smart Grid Applications
Profit from arbitrage on the spot market ?

Example of the fixed time based battery operation using y. 2010 Elspot market prices in price area Finland







- 10 MW, 50 MWh NaS battery system
- Approximated operation time 25 years (1 renovation after 12 years)
- Charging from 24 pm to 5 am at low price time
- Discharging am 9-12 and pm 17-19 at high price time.
- Estim. net cash flow covers 9% of the total cost (NPV)
  - No economic base for the investment

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ES in European Smart Grid Applications
Profit on the regulating market?

Each party operating in the electricity market must take continuous care of its power balance. E.g. the balancing power market in Finland maintained by Fingrid is part of the Nordic balancing power market. A Nordic balancing bid list is drawn up of all balancing bids by placing the bids in a price order.

The price for up regulation is always higher or equal to the spot price, while the price for down regulation is always smaller or equal to the spot price. All actors can give in bids and the TSO will buy the needed regulation power according to the standard market mechanisms.

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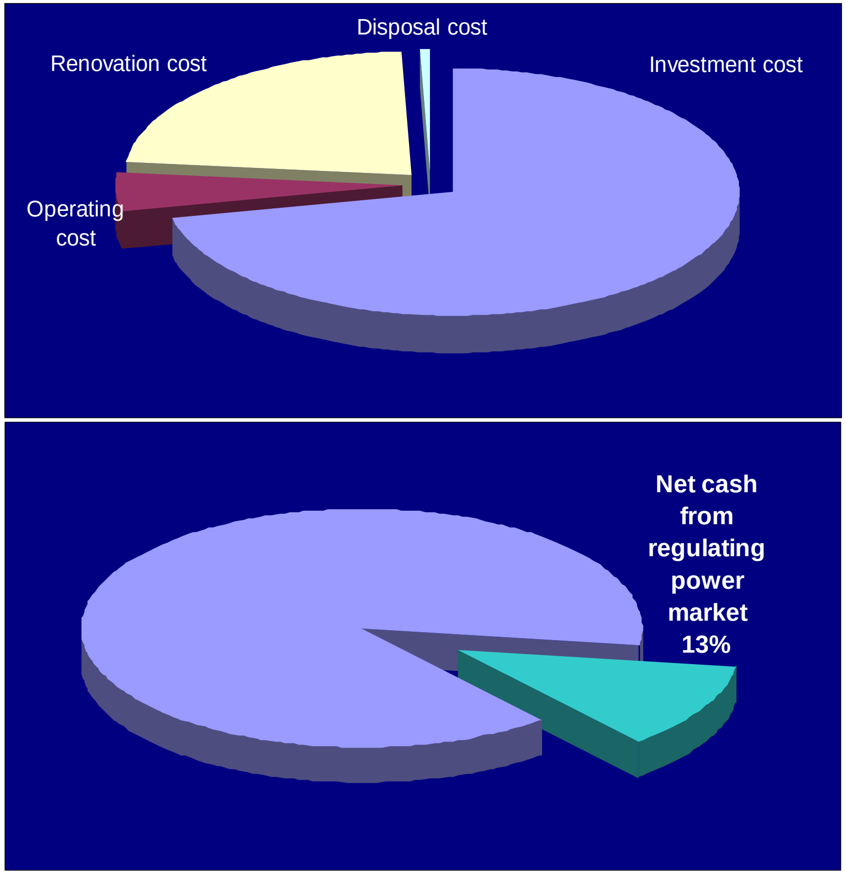
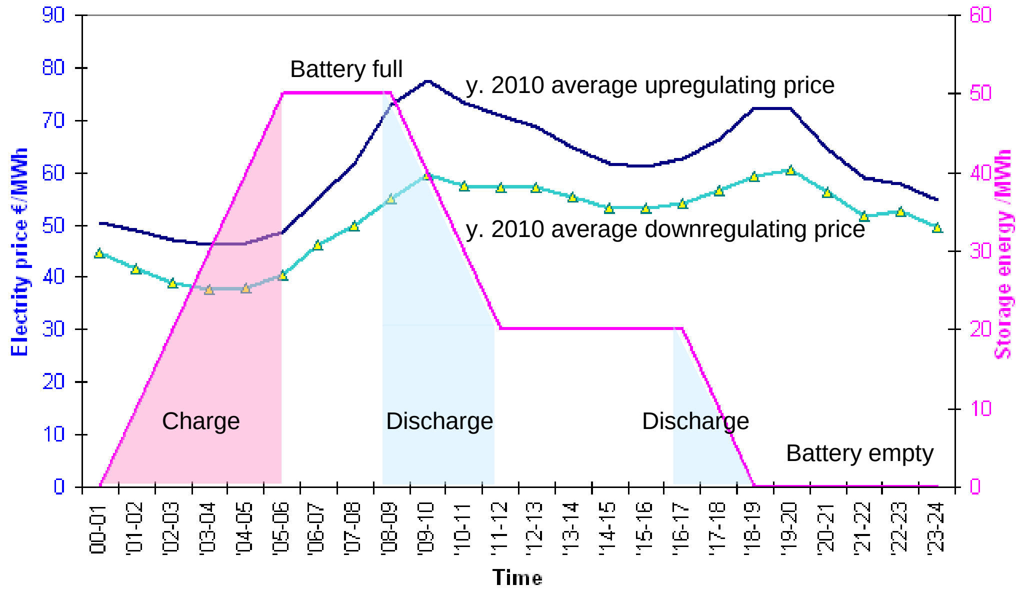
ES in European Smart Grid Applications
Profit from the balancing power market ?

Example of the fixed time based battery operation using y. 2010 balancing power market prices in price area Finland





- 10 MW, 50 MWh NaS battery system
- Approximated operation time 25 years (1 renovation after 12 years)
- Charging from 24 pm to 5 am at low price time
- Discharging am 9-12 and pm 17-19 at high price time.
- Estimated net cash flow covers 13% of the total cost (NPV)
  - ➢No economic base for the investment

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ES in European Smart Grid Applications Profit by selling ancillary services to the transmission system operator (TSO)?

ES benefits for TSOs in ancillary services (e.g. in Finland):

- Frequency control
- Fast disturbance reserve
- Control of power oscillation to support angle stability
- Control of the changes of demand or production (in an hour)
- To decrease the need of the short period power transmission
- To delay the grid investment
- In the black-start of the reserve power
- To control the voltage level with a reactive power source

Prices for ancillary services can be regulated or fixed and monitored by regulator and determined by market or negotiated/tendered (e.g. in Finland) => difficult to estimate possible revenues

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ES in European Smart Grid Applications
Profit by ancillary services?

Electric Supply Reserve Capacity within the inter-Nordic power system is taken care by Nordic countries. Finnish TSO Fingrid's current reserves in 2011:


Source: A123 systems

Energy storages could serve as

Reserve	Available capacity	Need
Frequency controlled normal operation reserve (50,1-49,9 Hz)	- Annually contracted, power plants 71 MW - Hourly market, power plants 50 MW - Vyborg DC-link 100 MW - Estonia DC-link 50 MW	136 MW *)
Frequency controlled disturbance reserve (49,9-49,5 Hz)	- Annually contracted, power plants 244 MW - Hourly market, power plants 298 MW - Disconnectable loads 40 MW	220-240 MW **)
Fast disturbance reserve (manually activated)	- Fingrid's own gas turbines 615 MW - Contracted capacity, gas turbines 203 MW - Disconnectable loads 395 MW	880 MW ***)

*) In the Nordic system total 600 MW, which is divided between the Nordic countries annually in proportion to the annual consumption.
**) The volume corresponding the largest dimensioning fault in the Nordic system is divided between the Nordic countries weekly in proportion to the dimensioning faults.
***) Volume corresponding to a dimensioning fault.

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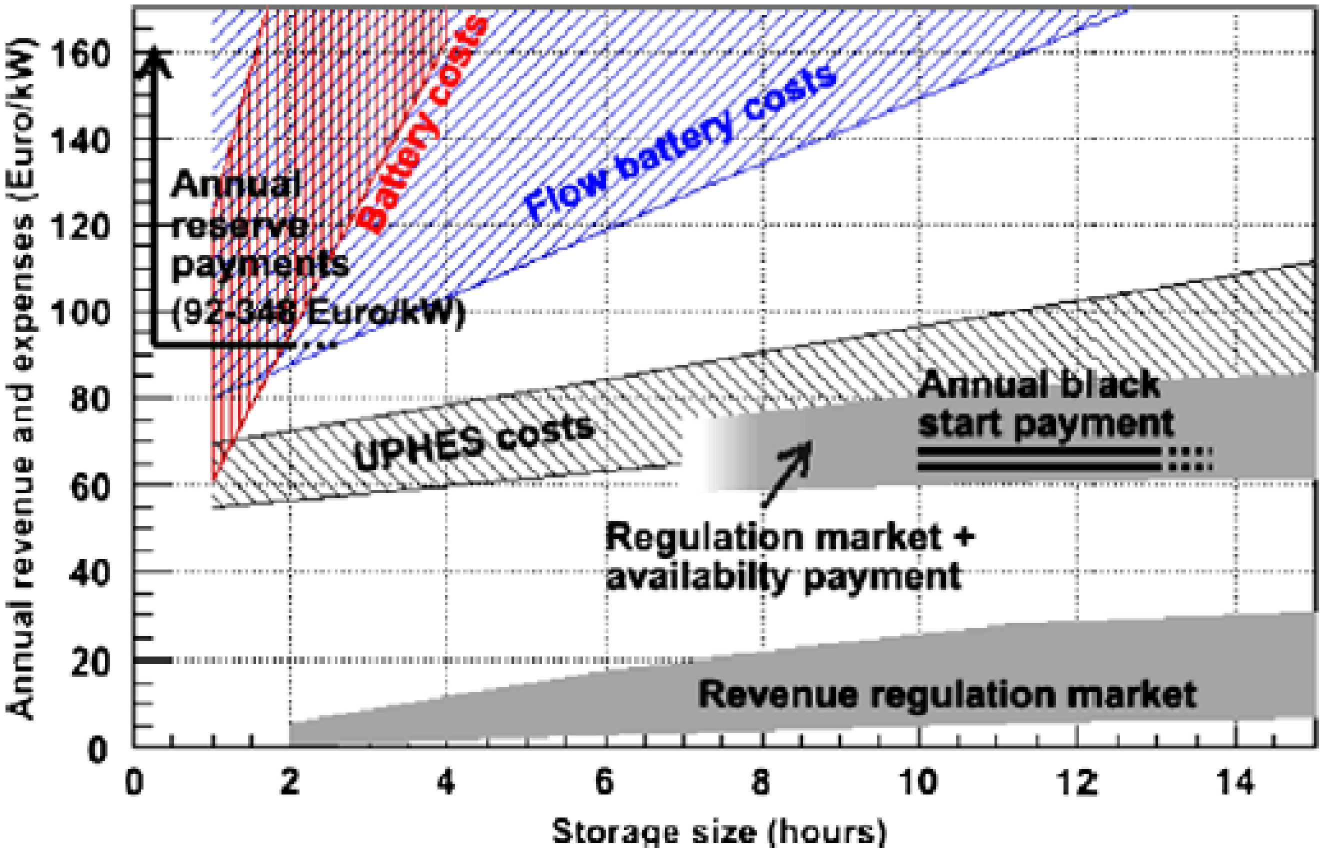
ES in European Smart Grid Applications
Profit by ancillary services?

According to the Danish study*) the highest annual revenues (€/kW) can be made on the market for fast reserves and it is likely that large battery systems can make profits on this market today in Denmark



*) Ekman, C.K. & Jensen, S.H. Prospects for large scale electricity storage in Denmark. Energy Conversion and Management 2010, Vol. 51, Issue 6, pp. 1140–1147

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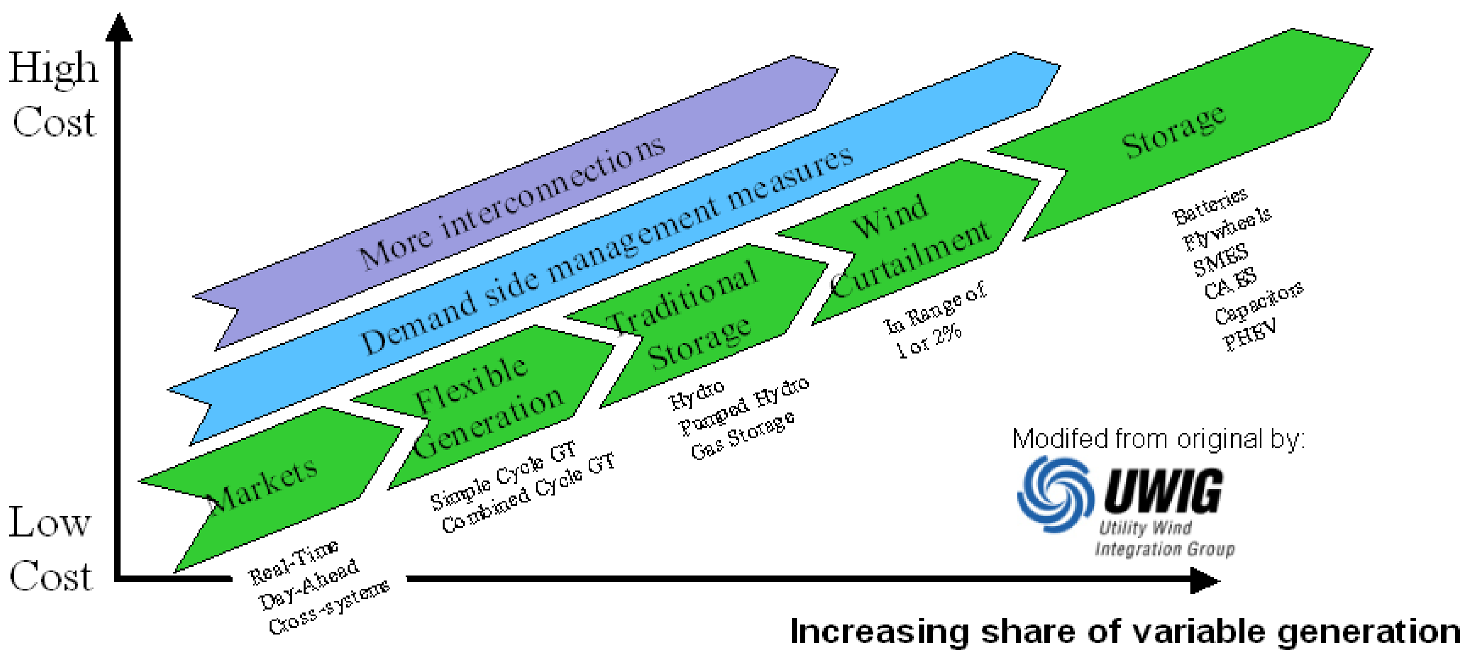
ES in European Smart Grid Applications
Other benefits of ES: Increase of flexibility

High penetration of variable generation (wind, solar PV, etc) can increase the need to further support power system flexibility

- **However electricity storage is today the most expensive option to increase flexibility**



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ES in European Smart Grid Applications Conclusions - Future work

For more accurate cost estimations:

- More accurate energy storage price information should be shown by manufacturers (inc. recycling prices and GHG values from manufacturing)
- Decrease or eliminate surcharges e.g. grid access tariffs

For more accurate benefits estimations:

- More accurate energy storage environmental impacts information
- Further work to be able to identify all possible stakeholders
- Further work to be able to identify all possible benefits for different stakeholders in the country and European level
- Further work and co-operation to be able to identify and inform of the value of possible benefits

Overcome regulation barriers

Contribute feed-in tariffs for energy storages?

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