Storage as a flexibility option for the European energy system

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21st January 2016

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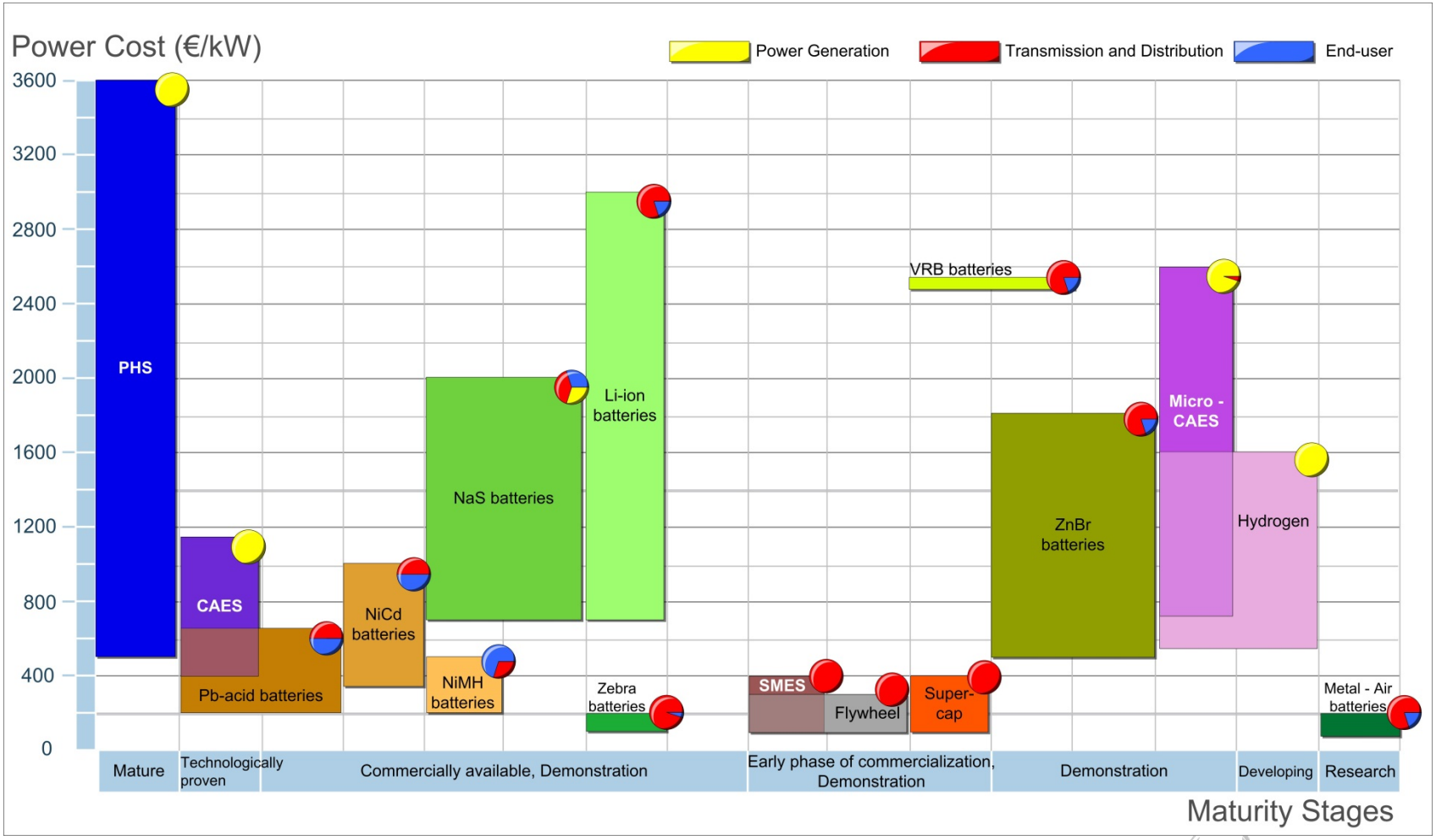
the European Commission's in-house science service

A portfolio of storage technologies for different applications



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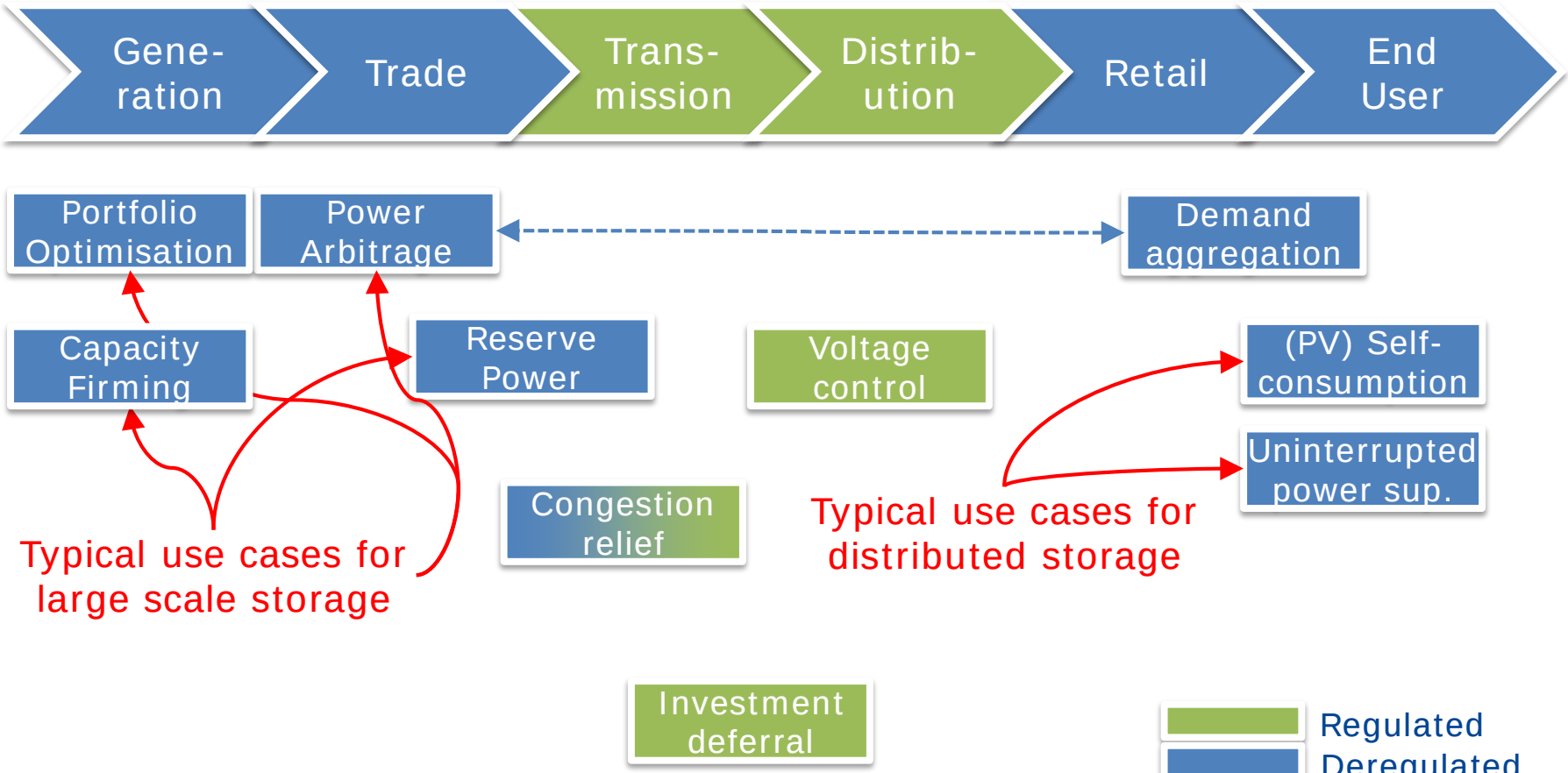
European Commission

Storage can deliver services along the entire electricity value chain …

Electricity value chain



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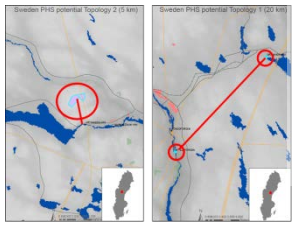
Would there be enough potential sites for pumped hydro storage in Europe?

GIS based assessment of 21 Member States + 5 other European countries (BA, CH, ME, NO, RS)[1]

Topology 1

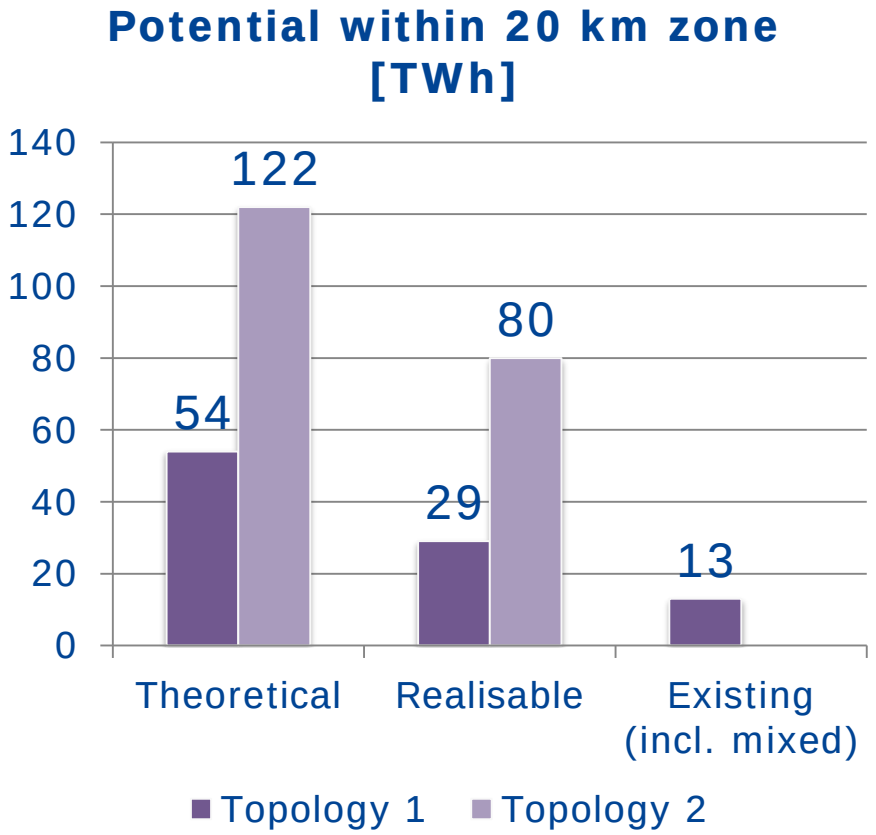
one existing reservoir



Topology 2

linking two reservoirs

Constraint	
Max distance between reservoirs	1, 2, 3, 5, 10, 20 km
Minimum head	150 m
Min new reservoir capacity	100 000 m^3
Mini distance to inhabited sites	500 m
Min distance to trans. Infra.	200 m
Min distance to UNESCO site	500 m
Max distance to trans grid	20 km
Min distance Natura 2000	not within



1) Gutiérrez et Lacal e2013 - Assessment of the European potential for pumped hydropower energy storage, JRC report EUR 25940 EN

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Will large scale storage become the facilitator for RES-E integration?

Drivers

- Increasing RES-E penetration will require flexibility
- PHS and CAES mature technologies
- Sites available for CAES[1] and some additional Pumped Hydropower

GEN | TRAD | TRANS | DIST | RET | END

Barriers

- Power market depressed
- Changing shape of daily power price pattern (loss of mid-day peak)
- High CAPEX requires long term visibility

Key questions

- Additional income streams through stacking of benefits
- Storage investment case under different market regimes
- Competition with other flexibility options

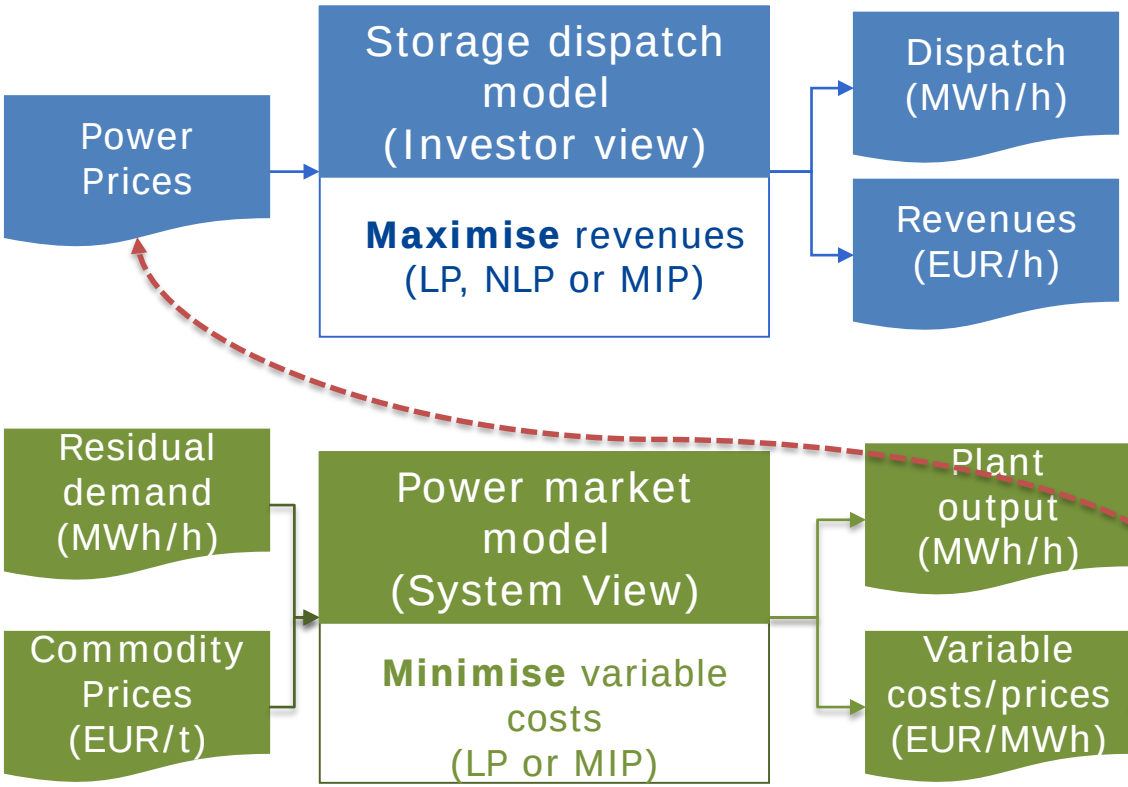
1) Compressed Air Energy Storage

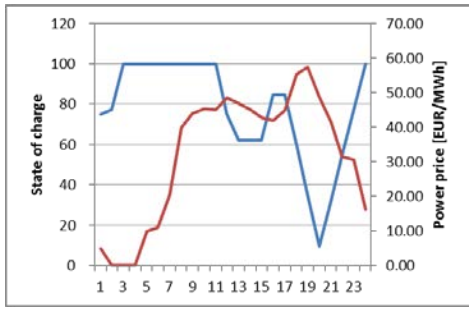
The value of storage depends on the point of view taken in the assessment

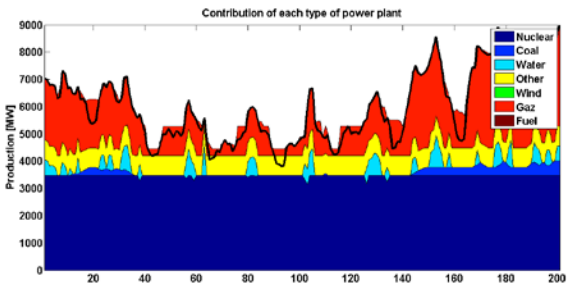
Type of study	Process	Mathematical formulation
Investor value	Assess the ***profitability*** of power storage from the ***investor's*** point of view	***Maximise profit*** resulting from (possible) storage revenue streams
System Value	Assess ***benefit*** of adding storage to the generation ***system***	***Minimise total costs*** of operating the power system

Different mathematical tools are used for investor and system studies

Input **Output**







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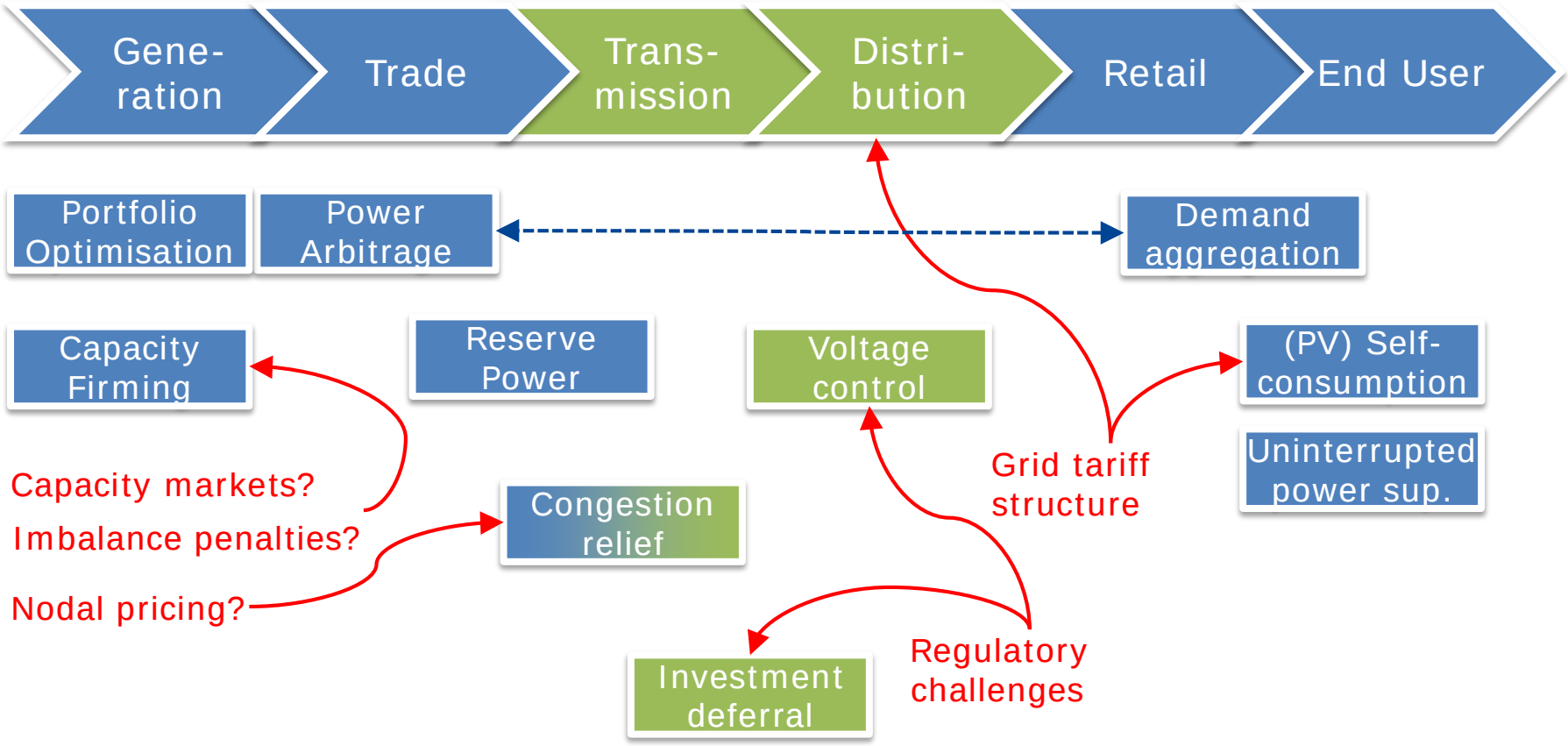
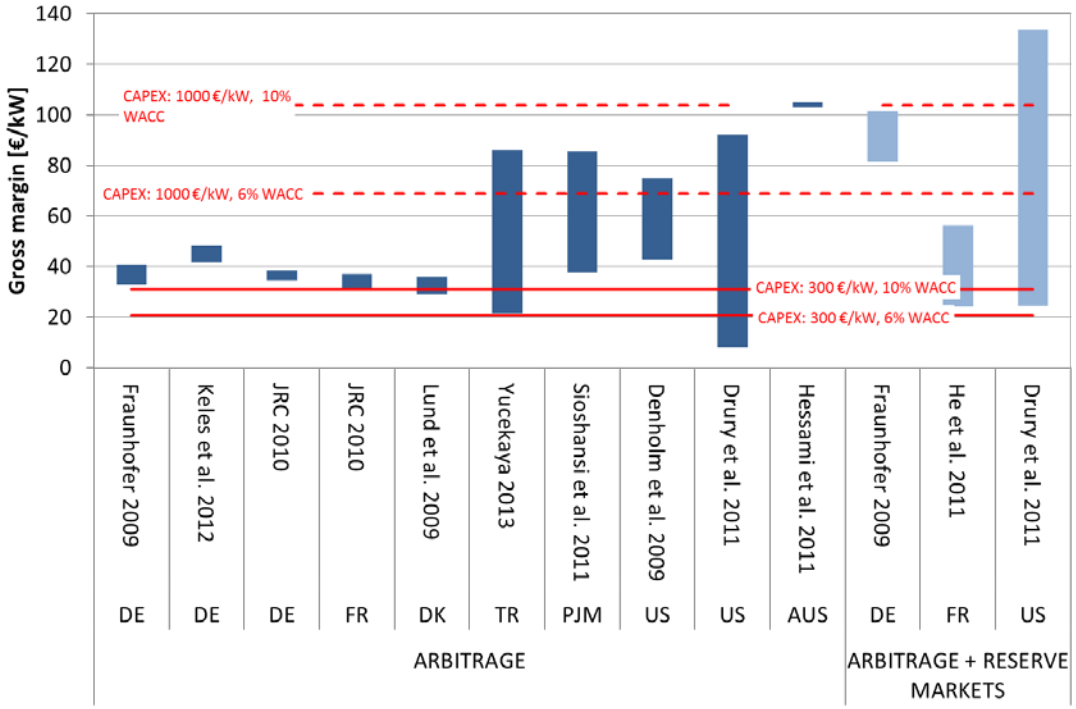
The investor value of storage also depends on the regulatory environment

Electricity value chain



Results of investor value studies vary widely with assumptions

CAES[1] study range of results



Drivers

Market

- Power price profiles differ across different markets and change over time

Storage use case

- Stacking services can generate extra revenues

Model assumptions

- Perfect foresight hypothesis vs estimation of forecast error

→ Profitability is not a given for electricity storage!

1) Compressed Air Energy Storage

Recent system studies cast doubts on need for large scale storage in mid term

Study	Time horizon	Key findings
Agora Energiewende	Germany 2030-50	• Other flexibility options less expensive if RES-E capacity between 40%-60% (2030 horizon) • Storage can add system value for 90% RES-E system (2050 horizon)
Etude PEPS	France 2030	• No significant increase of storage need by 2030 (+1 – 1.5 GW) if PV below 30 GW • Largest value driver is "capacity value" i.e. avoided investments in gas turbines

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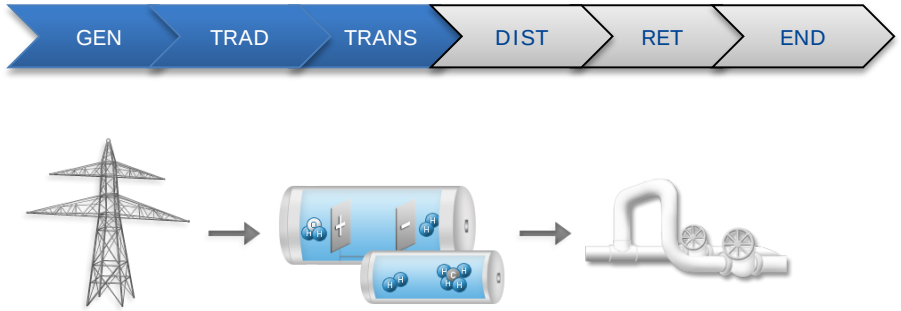
Power to gas promoted as a key technology for high RES-E systems

Drivers

- High energy density
- Low energy storage cost (€/kWh)
- Long term storage option
- Connects multi energy vectors



Barriers

- Low round trip efficiency
- Standardisation and regulatory issues for injection into gas grids
- Competition with natural gas (flexibility) and battery storage (mobility)

Key questions

- Absolute and relative economic benefits of competing power to gas options
- Attractiveness of different use cases under different regulatory assumptions
- Technology roadmap for a hydrogen economy

Different conclusions regarding the value of hydrogen and "power 2 gas"

Agora Energiewende[1]

- Study on short (PHS, CAES) and long-term (H2) storage
- Value of different storage options for future German low carbon energy system with very high RES-share

France Strategie[2]

- Work note on the economics of hydrogen and power to gas
- Costs of hydrogen production (now and in future) compared to current costs of gas

- Low need for storage investments before 2030 (existing system can cope)
- P2Gas could for chemical industry and *transport could break even with oil in mid 2020s* …
- … under slightly optimistic assumptions (30-50 €/MWh, 4000-5000 h/a utilisation

- Hydrogen from P2Gas cannot compete with hydrogen from steam reforming for foreseeable future
- Costs of hydrogen car at 13 €/100km vs 3.5 €/100 km for diesel car
- CO2 price of 993 €/t to break even
- 70 €/MWh price, 2000 h/a utilisation

1) Fürstenwerth et al. 2014, Stromspeicher in der Energiewende
2) Beeker 2014, Y a-t-il une place pour l'hydrogène dans la transition énergétique

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PV self-consumption plus storage increasingly competing with grid

Drivers

GEN → TRAD → TRANS → DIST → RET → END

- Increasing PV share requires solution for distribution grids (e.g. over voltages)
- First commercialisation of products (e.g. Tesla Power Wall) & incentives (e.g. DE)
- Consumer discount rate below utility discount rates

Germany: the first EU state to penalize the self-consumption of solar energy

27/01/2014

The German government has approved on Wednesday a new owners of renewable energy plants for their own use of electr bills. The changes would affect photovoltaics and are now pa cabinet is expected to officially sign off on the draft law in Ap vote on it in June and could become law on August.

The levy will only apply to new rooftop installations above 10kWp fitt solar generated electricity will be required to pay a €0.044kWh char exempted from the tax but they only make up 17% of new self-cons investments in the technology in the nation that has the most instal households are now paying more for electricity than any other natio bills increased 18 percent to 8 cents per kilowatt-hour this year. BSW-Solar is calling on the governmer

Barriers

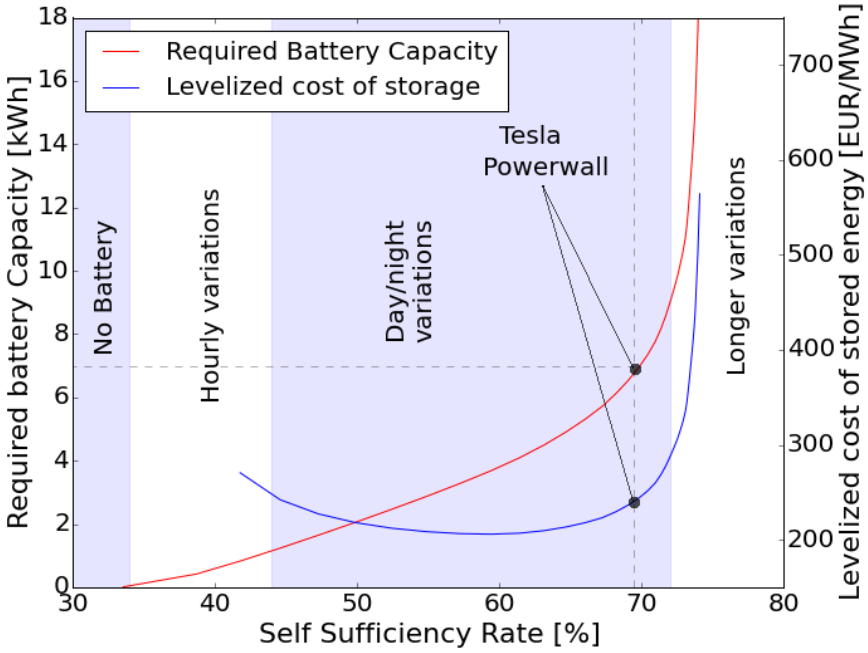
- Counterproductive from grid operator point of view (less revenue, same costs)
- Need to coordinate dispatch in case of further growth?

Key questions

- Potential to reduce battery CAPEX
- Economics for self-consumer under different regulatory schemes
- Implications on distribution grid sizing and operation

Batteries can increase self-sufficiency of PV-prosumers, but only to a point …

Required capacity and costs as a function of self-sufficiency rate[1]



- Self-sufficiency of 30% in absence of batteries increases to 70% if 10kWh battery deployed
- Size and costs increase sharply when trying to increase self-sufficiency beyond 70%
- Cost also increase when undersizing the battery due to fixed costs (installation, cables)

Prosumers will likely not abandon the power grid, but they will underutilize it.

1) Own analysis, based on real household consumption and PV production profiles for Belgium

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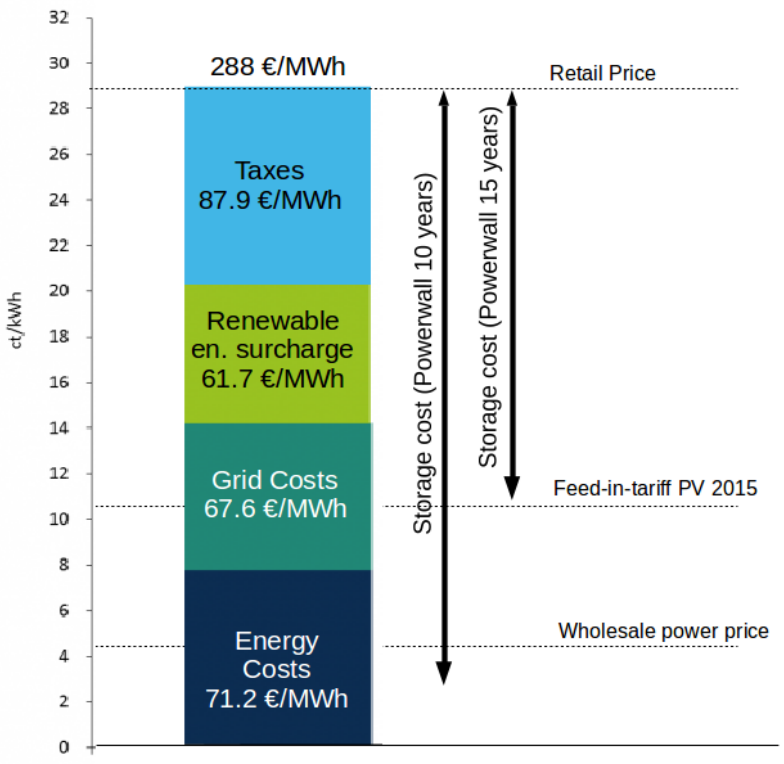
There might be no economic incentive for storing solar PV energy

Battery costs vs total retail price for DE



- Retail prices consist of energy costs, grid costs, RES-E surcharge and taxes
- PV remunerated with FIT
- Storing (and self-consuming) economically attractive if costs lower than (opportunity costs) of lost FIT
- Profitable in DE if battery lifetime is 15 yrs, not profitable if lifetime is 10 yrs
- Studies show that buyers of home batteries not only motivated by economic motives[1]

1) ISEA RWTH 2015 – Wissenschaftliches Mess- und Evaluierungsprogramm Solarstromspeicher Jahresbericht 2015

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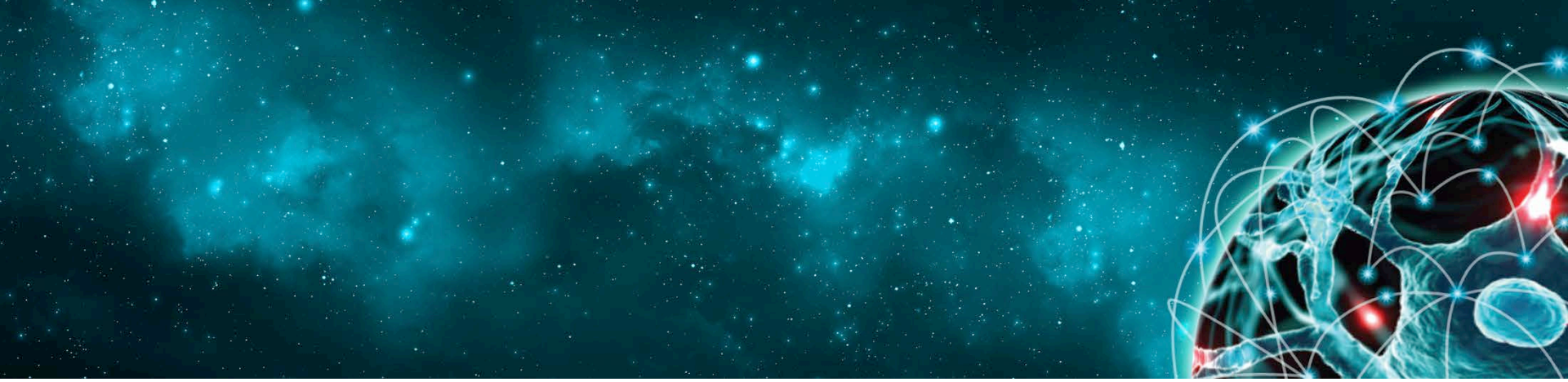
Conclusion

- There is no shortage of technology options for electricity storage
- Storage fulfils a number of roles in the power system
- The value of storage depends on the perspective of the assessments
- Storage might have a systemic value but this does not mean that investors can recover this
- Investor value strongly depends on regulatory details, market structure, subsidies etc.
- Competing flexibility options might be more attractive than storage in some situations



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