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Technical opportunities and barriers for utility scale energy storage

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Berlin, 23 October 2014

Joint Research Centre

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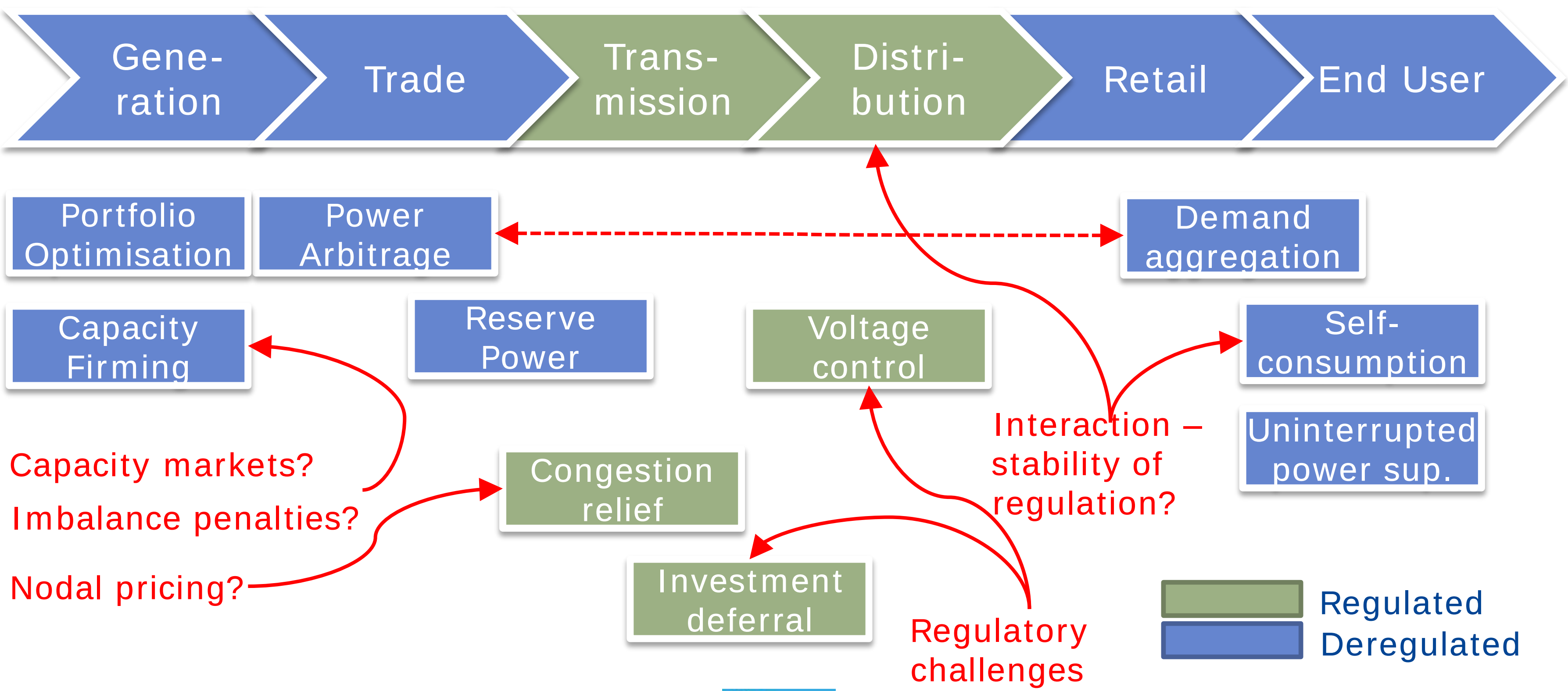
Overview

- ✓ **Potential role of energy storage**
- ✓ **RD&D questions**
- ✓ **Storage value**
- ✓ **Conclusion**

Storage considerations along the electricity value chain

Electricity value chain



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Storage is "competing" with other options for providing flexibility[1]

	Supply over 365 days of year	Daily plant optimisation	Adjust production within an hour
(Flexible) power plants	Gas (CCGT, OCGT) Coal, (Nuclear)	Hydro reservoir, OCGT, CCGT, Coal, (Nuclear)	Nuclear, Coal, Gas (frequency control)
Market interconnection	Seasonal power trade (e.g. FR <-> DE)	Market coupling and arbitrage	Target model? Grid codes?
Demand response	-	Heavy industry (e.g. Al smelter)	Heavy industry (e.g. Al smelter)
Flexible RES-E	Biomass	Curtailment?	PV Smart inverters? Wind FCR?
Energy storage	Hydro reservoir, H2?, thermal storage?	PHS, CAES, Batteries?	Flywheels, batteries PHS?, CAES?

1) Additional system needs (e.g. voltage control, black start capability, congestion management not shown here …)

Selected inputs by the stakeholders
SET-Plan Integrated Roadmap *(work in progress)*

Advanced R&D

Enhanced materials
- High temp steel
- Electrolytes
- Nanostructures

New technologies
- LiS, Zn/Air

Improved technologies
- Variable speed PHS
- Adiabatic CAES
- Very low head turbines

Interfaces
- SCADA[1]
- ICT

Industrial research and demo

System simulation
- Embedding storage
- EU standard models

New technology field tests and demos
- Central
- Decentralised

System integration field tests and demos
- SCADA
- ICT

Manufacturing process
- Allow scalability
- Recycling of materials

Innovation and market uptake

Standardisation
- Interfaces
- Assessment schemes

Global business case demo and evaluation

New environments
- Behind the fence
- Contractor models

Health Safety and Environment solutions
- PHS landscape impact
- CAES brine deposition
- Battery fire hazards

1) Supervisory Control and Data Acquisition

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Will Adiabatic Compressed Air Energy Storage (A-CAES) be ready in time?

Drivers

- The main large scale alternative to pumped hydro for 'flat' regions
- No dependence on natural gas as heat stored
- Based on well-established turbo-machinery and heat storage

GEN | TRAD | TRANS | DIST | RET | END

Barriers

- Very small existing base for CAES (only 2 plants worldwide)
- Currently little financial incentives to deploy the technology
- Geology, competition for reservoirs?

RD&D needs

- Successful demo to establish confidence (latest projects delayed)
- Road mapping and R&D monitoring to understand technology innovation needs
- Continued Techno-economic evaluation and power system studies to evaluate the likely market environment

RD&D questions

Can thermal storage, DSR[1], E-vehicles push aside electricity storage?

Drivers

- Large, yet little developed potential for heat storage (el. heating, CHP, cold)
- Largely untapped potential for residential DSR
- Cost advantage w.r.t. electricity storage
- First deployment cases (DK, DE, FR)

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Barriers

- No transformation of energy back into electricity
- Might require behavioral change and regulatory challenges
- Infrastructure needs

RD&D needs

- Assess potential (TS, DSR, EV)
- Interactions of different sectors (power, heat, transport) with energy system models (e.g. JRC TIMES)
- Interaction with power system (Techno-economic case studies

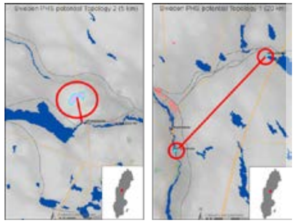
1) Demand Side Response

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

GIS based assessment of 21 Member States + 5 other European countries [1]

Topology 1

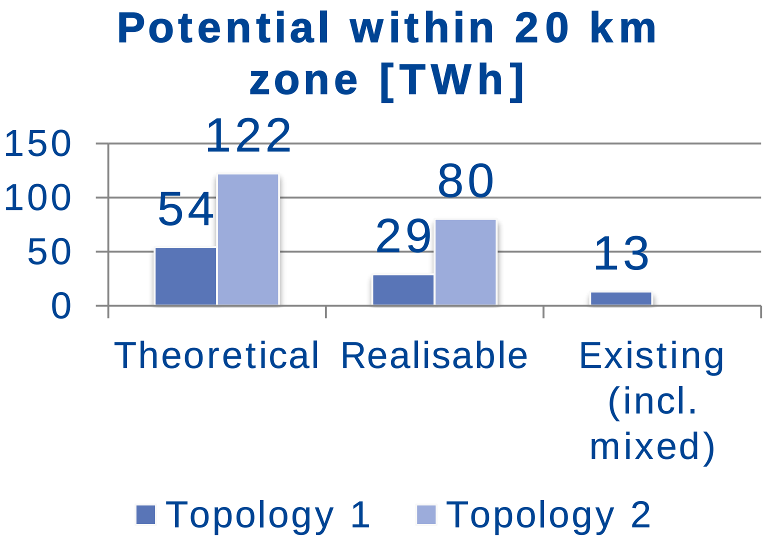
one existing reservoir



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 transmission grid	20 km
Min distance Natura 2000 co area	not within



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

Will storage technology be driven by a consumer pull or industry push?

Drivers (for pull)

- Success story of Li-ion batteries originally developed for consumer goods
- E-vehicles provide potential for further consumer driven technology deployment

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vs

Barriers (and counterfactuals)

- Potentially unstable regulation of local storage
- Development of NaS in coordinated effort by Japanese stakeholders and current large scale redox flow batteries suggest attractiveness of push approach

RD&D needs

- Understand innovation processes for historical and current storage technologies
- Mapping of ongoing R&D activities

Will PV self-consumption plus storage make electricity grids "redundant"?

Drivers

- Increasing PV share requires solution for distribution grids (e.g. over voltages)
- First commercialisation of products (DE) after driven by incentives (e.g. DE)
- Consumer costs of capital below utilities

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 governme

Barriers

- Counterproductive from DSO point of view (less utilisation, same costs)
- Decentralised storage can also increase grid needs if dispatched according to market signals
- To a degree driven by high fees and taxes on power →unstable?

RD&D needs

- Improve battery CAPEX
- Understand business model under different regulatory schemes
- Implications of distributed storage on distribution grid sizing and operation (distribution grid models)

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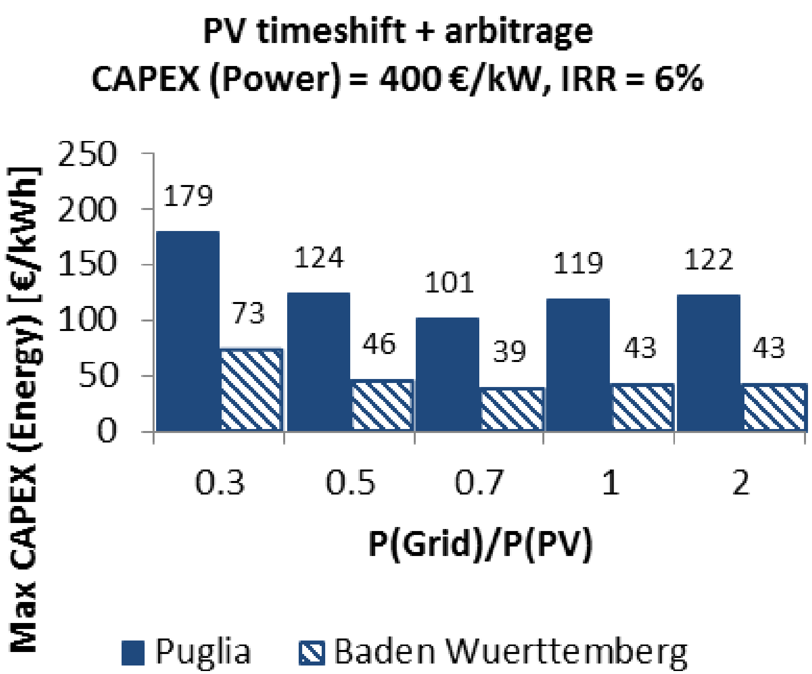
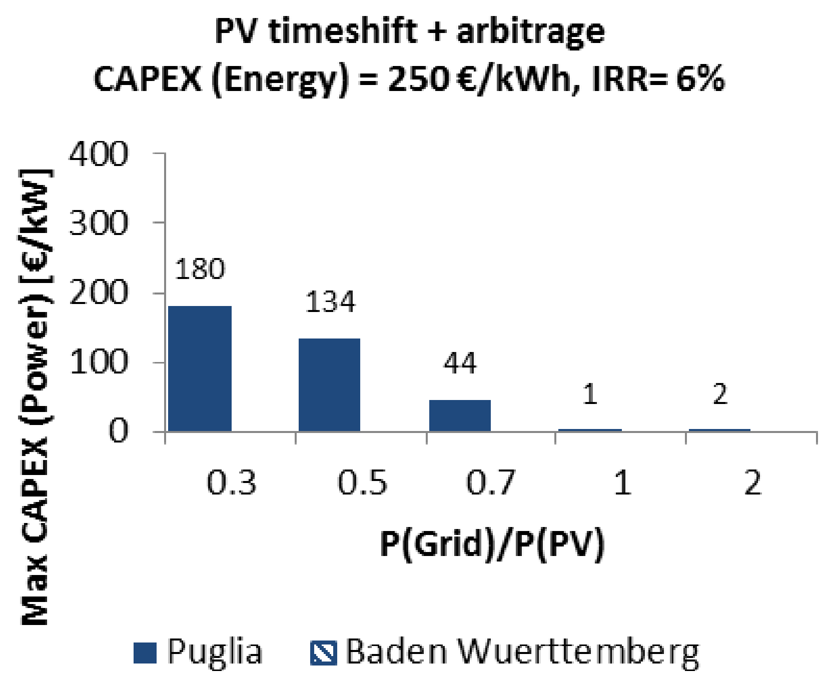
Storage value can be assessed in two fundamental ways

	Mathematical formulation	Typical application
Engineering Studies	***Maximise profit*** resulting from (different) storage revenue streams	Assess the ***profitability*** of power storage from the ***investor's*** point of view Applied to current system, often arbitrage + reserve
System Studies	***Minimise total costs*** of operating the power system	Assess ***benefit*** of adding storage to the generation ***system*** Applied to future systems, x-value chain assessment

Storage could generate 6% IRR in IT if battery CAPEX at 100–150 €/kWh

Storage Energy (left) and power (right) CAPEX for obtaining an IRR of 6%[1]

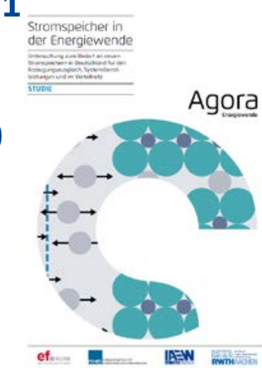




1) Zucker et Hinchliffe 2014

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

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- 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

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- 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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A number of regulatory hurdles could be addressed

Technical rules

- Application of final consumption fees (grid and RES-E) to storage, even if storage does not constitute final use of the energy

RES Market integration

- Payments for curtailment to RES producers, without an incentive to encourage productive use of the curtailed electricity

Ownership and right of access

- Lack of clarity on rules under which storage can access markets (e.g. TSOs and DSOs generally not allowed to own and operate storage)
- Missing rules on access of storage to the ancillary services market

Conclusion

- Storage is not a simple asset class → rather it can have many different functions
- RD&D needed for a number of storage technologies
- Assessing the value of storage does not always yield simple answers and many assumptions might be inadequate

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Thank you!