

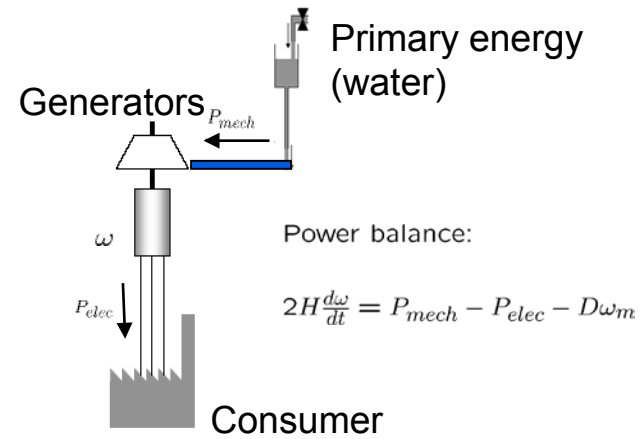


Martin Näf, ABB Switzerland, Corporate Research – May 22, 2015

Energy Storage

Current Developments and Challenges

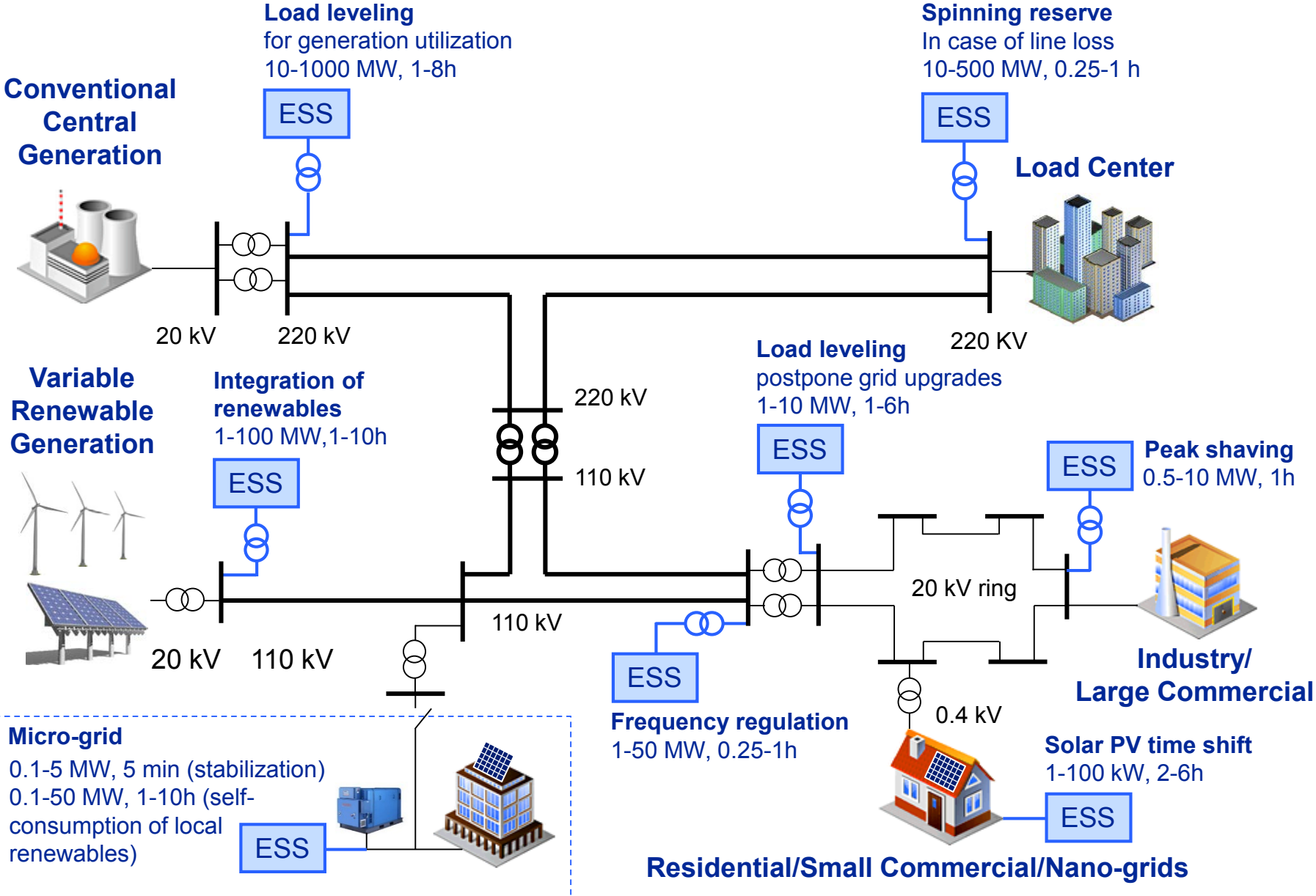
Electric Energy System Balance Fundamentals



Storage has always been fundamental to the balance of the electric power system

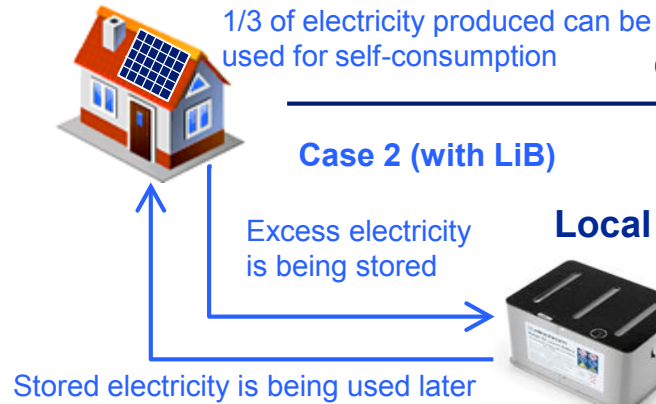
- Kinetic energy of rotating mass in generators
- Primary energy source (e.g. water)

Applications of Energy Storage: Electric Grid



End-user Solar PV Self-consumption (Germany)

Local PV to a household with an annual consumption of 3500 kWh



Distribution grid



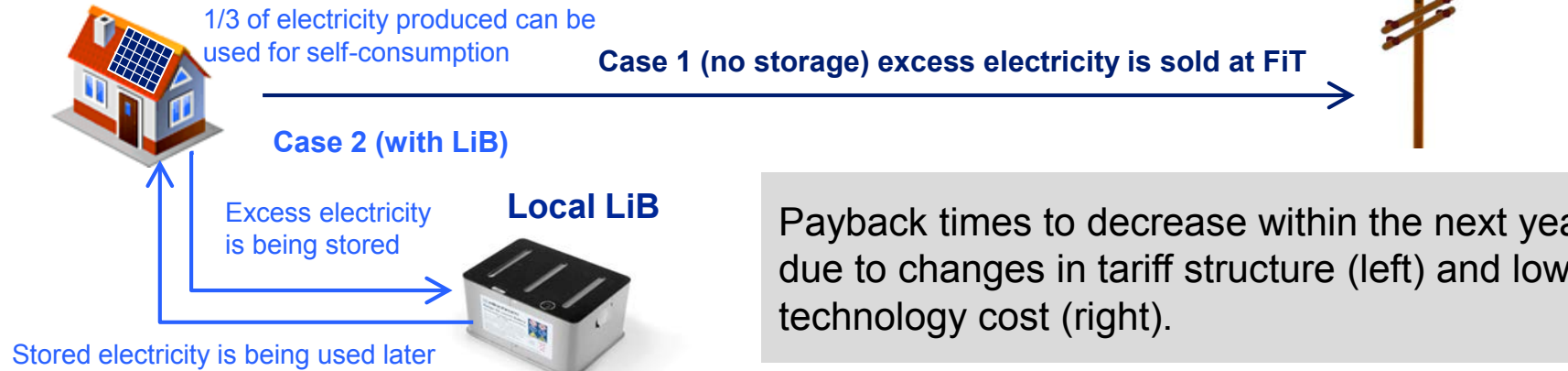
Electricity retail tariff \$/kWh 2012-2014:	
• Canada/N.Territories	1.20
• Denmark	0.41
• US/Hawaii	0.38
• Italy	0.28
• France	0.20
• Brazil	0.16
• Switzerland	0.15
• Indonesia	0.09
• US//N.Dakota	0.08
• China	0.08
• India	0.08
• Saudi Arabia	0.02

	Today w/o subsidies	Today w/ subsidies*	2020 w/out FiT
Annual production, kWh/kWp	1000		
Feed in Tariff, €/kWh	0.13		0.00
Residential tariff, €/kWh	0.29 (0.39 \$)		0.5 (0.68 \$)
System efficiency, %	85		90
Solar PV investment cost (€/kWp)	1'700	1700	1000
End-customer BESS, €/kWh	1'650	1100	700
Investment cost for average household (3500 kWh/y), € (PV 3.9 kWp, BESS 7.5 kWh)	19'400	15'300	9'170
BESS OPEX, €/kWh/year	25	25	0
Payback time w/out discount, years	29	23	5

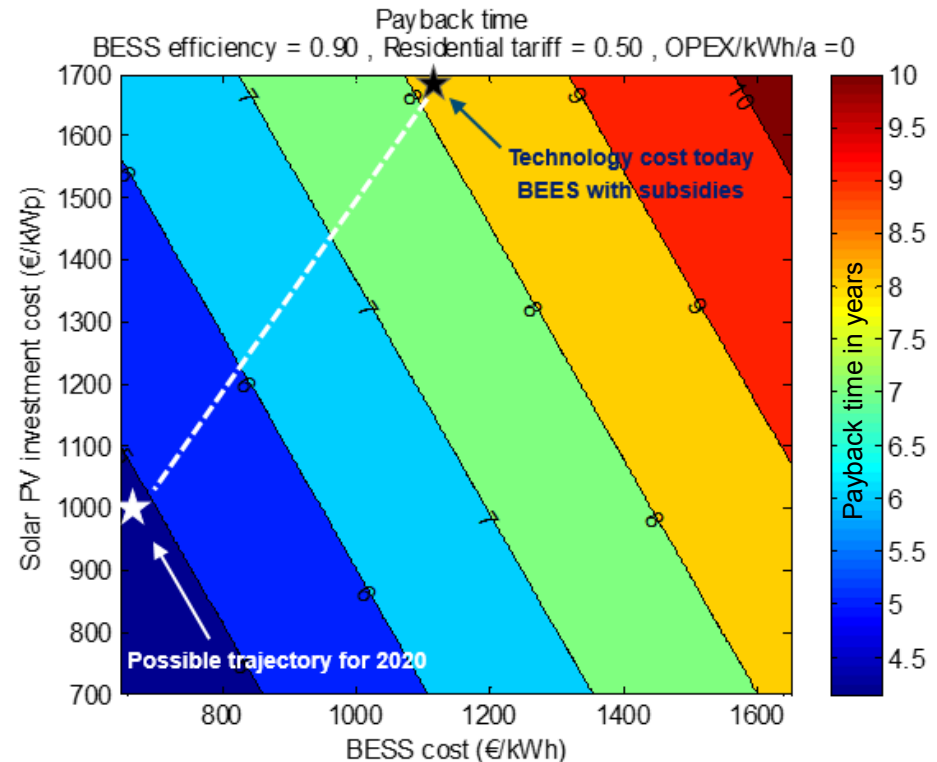
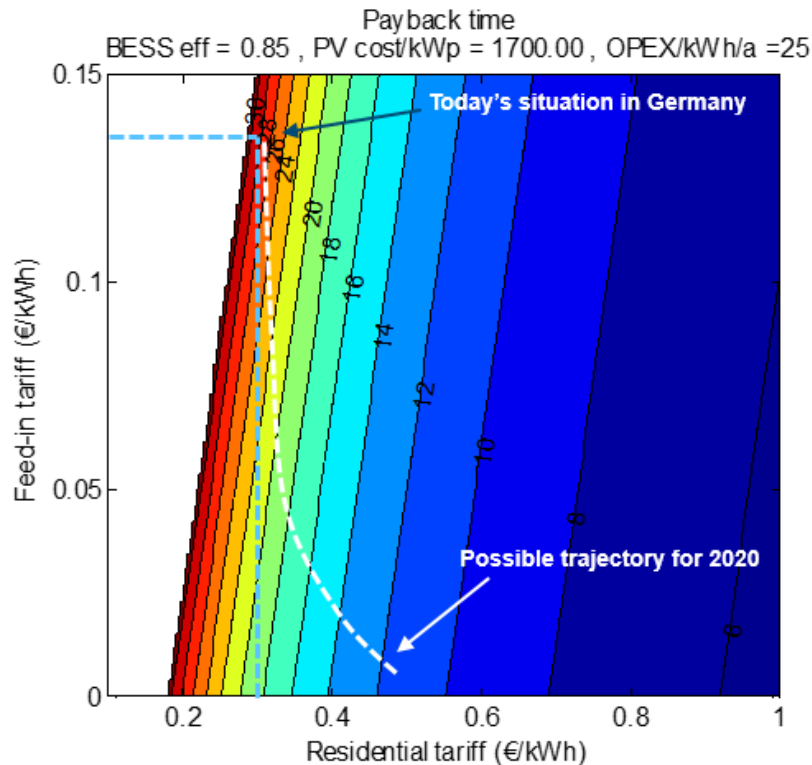
*) 30% subsidy on battery cost (for PV systems <30 kW)

End-user Solar PV Self-consumption (Germany)

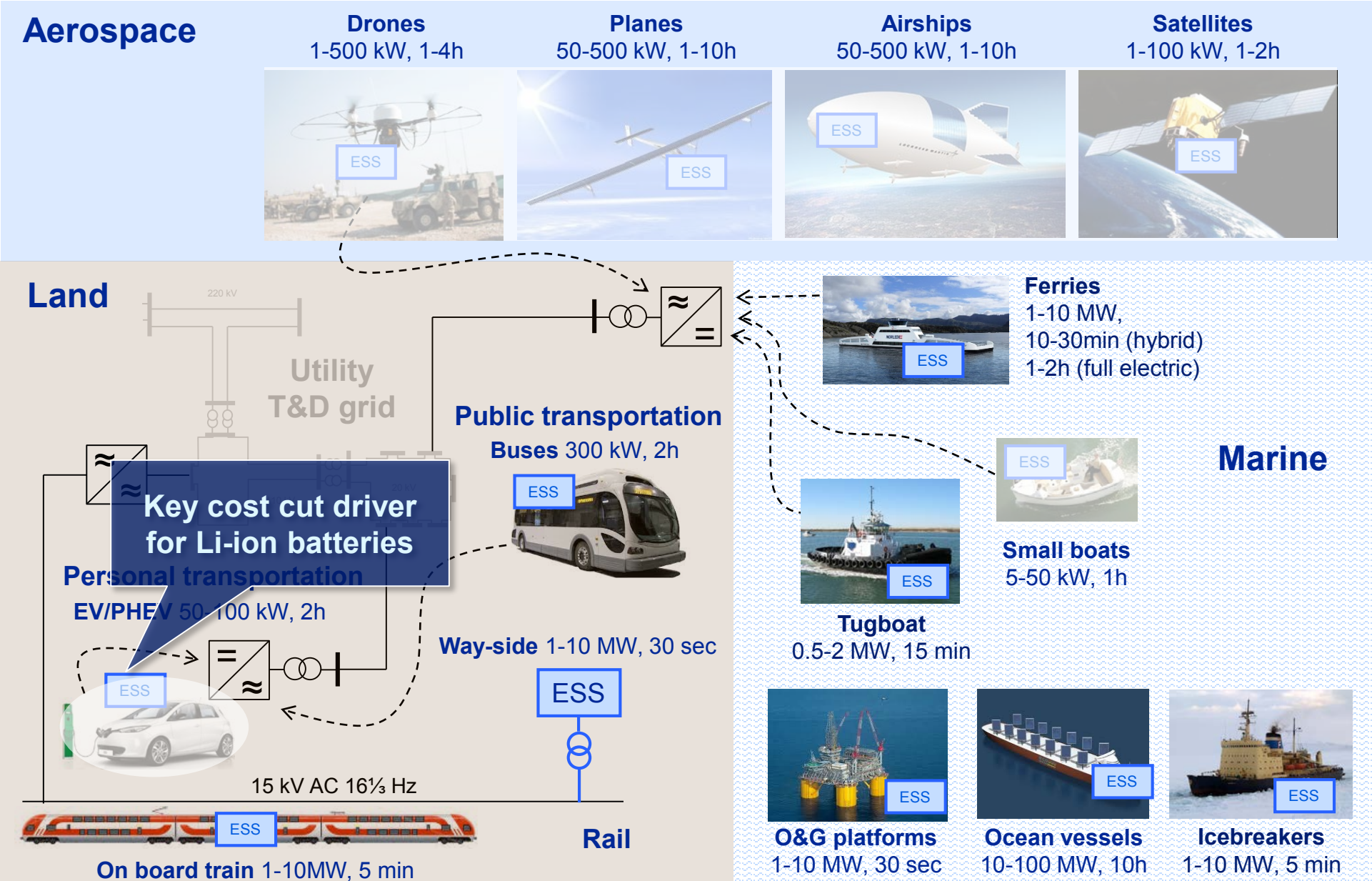
Local PV to a household with an annual consumption of 3500 kWh



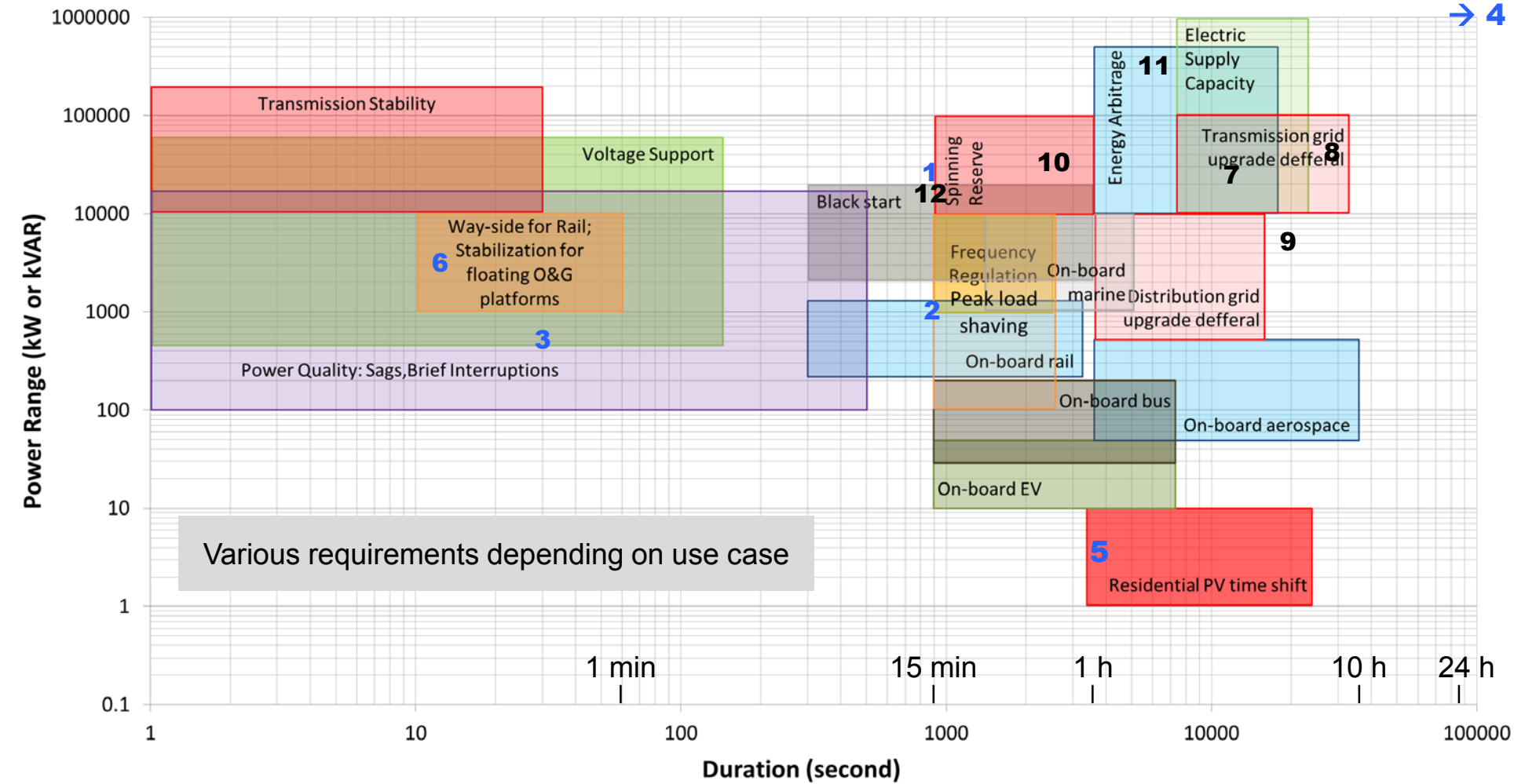
Payback times to decrease within the next years due to changes in tariff structure (left) and lower technology cost (right).



Applications of Energy Storage: Mobility



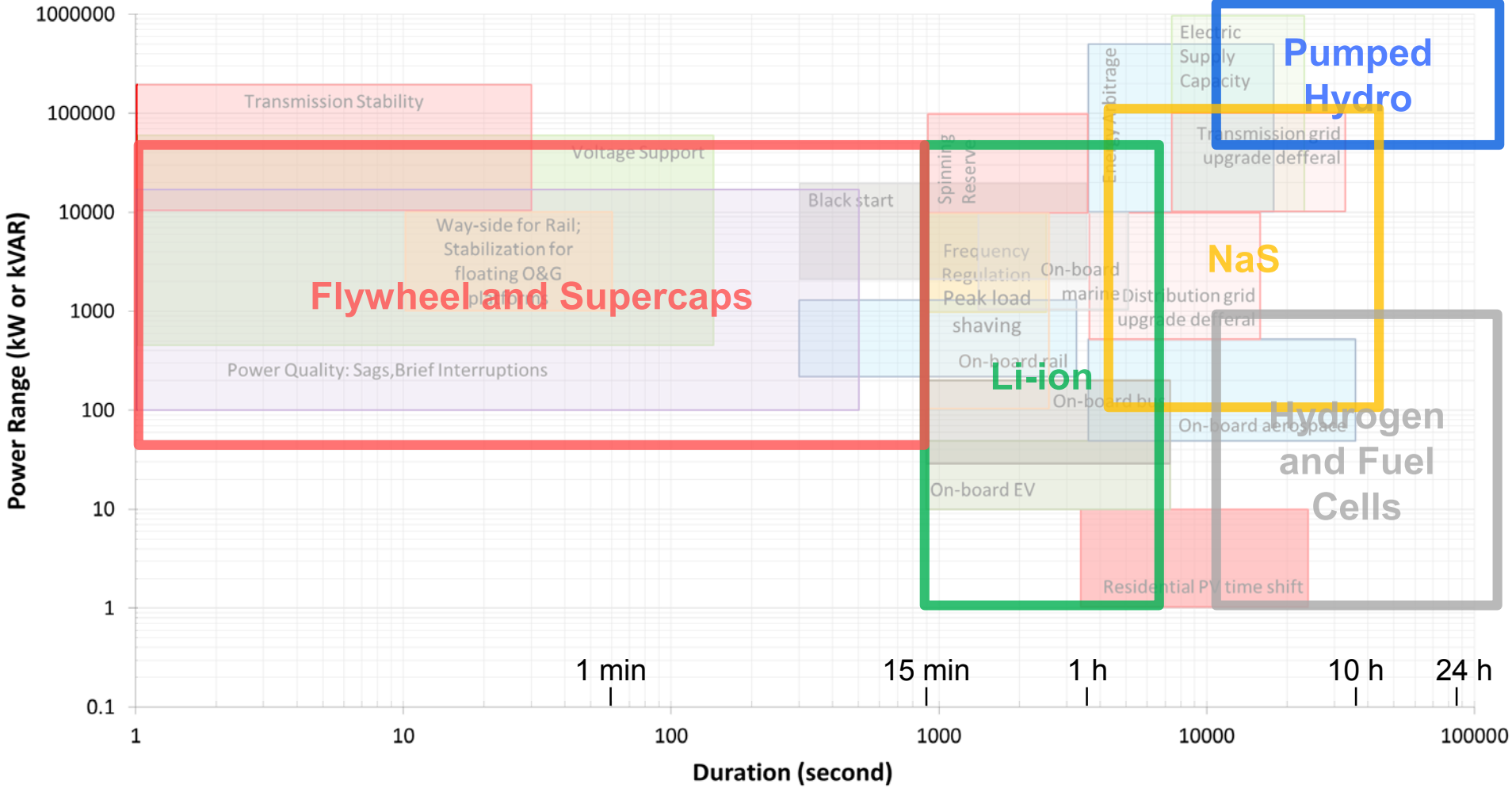
Energy Storage Applications Landscape



1. ABB for GVEA, Alaska, US
NiCd, 27 MW / 15 min
2. ABB for EKZ, CH
3. ABB for Horizon Power, AU
Flywheel, 500 kW / 0.5 min
4. ABB for Linthal, CH
PHS, 1000 MW / 120 h
5. ABB PowerOne
Li-ion, 4.6 kW / 1h
6. ABB for metro Warsaw, PL
S-Cap, 3.3 MW / 12 s

7. Primus Power, USA
Flow bat, 25 MW / 3 h
8. Rokkasho, JP
NAS, 34 MW / 7.5 h
9. Zhangbei, China
Li-ion, 6 MW / 6 h
10. Xtreme, Duke Energy, US
Lead-Acid, 36 MW / 40 min
11. Huntorf, DE
CAES, 321 MW / 2 h
12. Beacon Power, NY, US
Flywheel, 20 MW / 15 min

Technology / Application Mapping



- - PHS
- - NaS
- - Li-ion
- - Flywheel/S-Cap
- - H2/FuelCells*

*) potential area in the future if cost is reduced

Storage technology suppliers select their targeted applications based primarily on the characteristics of their technologies. ABB is storage technology agnostic and can play across different applications










Energy Storage

Regulatory and policy framework

Regulation plays a central part in ESS business from planning and approval to final operation, e.g. it may address the following topics:

- System ownership (generation, T&D, load)
- Limitations on using a specific storage media (environment, safety, etc.)
- Market rules to reward a superior performance characteristics of ES
- Financial incentives (tax reduction, FiTs, direct compensation)

Today some countries are in the process of introducing new legislation to support a wider deployment of energy storage

							
Capacity Targets	California PUC 1'325 MW by 2020		500MW for f reg by 2017, 2GW total ES target by 2020	35 MW as pilots extended to 130 MW			
Favorable market rules or other incentives	FERC Orders 755, 784, 792 to reward fast responding units	Barely regulated, no clear guidance	Legislation for mandatory ES installation (large consumers) is under evaluation	Owned by TSO (TERNA), costs are recovered via tariffs	30% subsidy on battery cost (for PV systems <30 kW) to boost self consumption	Gov't subsidies for small & medium BESS (cost reduction up to 60%)	Ramp rate limits on newly built renewable plants (mainly PV)

Conclusions

Credits:
Alexandre Oudalov
and colleagues at ABB
Corporate Research
Center Switzerland.

Energy storage is an essential component for power systems operation

- Handling short term fluctuations
- Balancing production and demand

Energy storage options include many technologies beyond batteries

Innovation in energy storage is strongly driven by applications outside the traditional power systems domain

Economic operation of storage systems remains a challenge.

Power and productivity
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