Renewable energy penetration in Grids: Issues and Solutions

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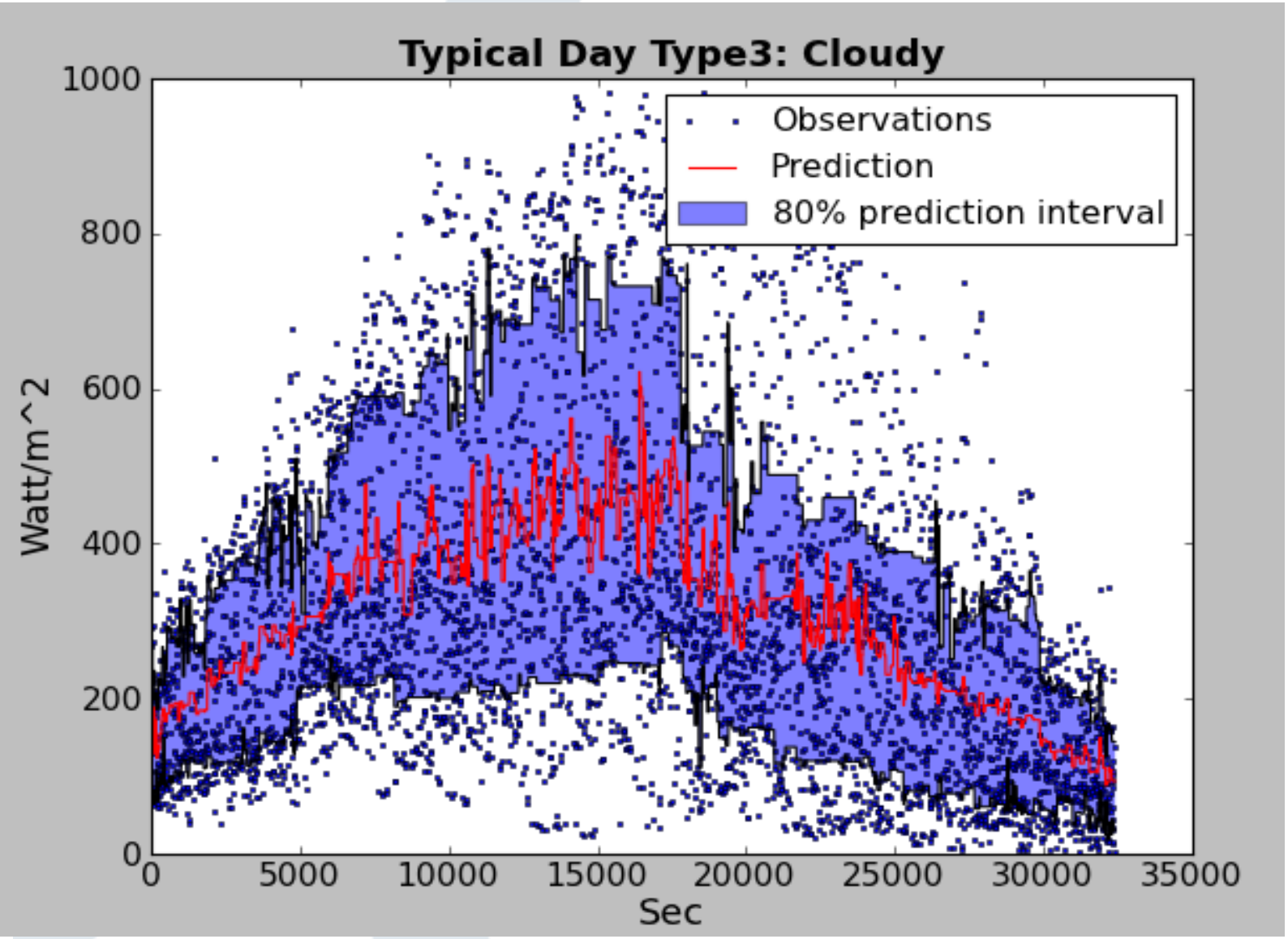
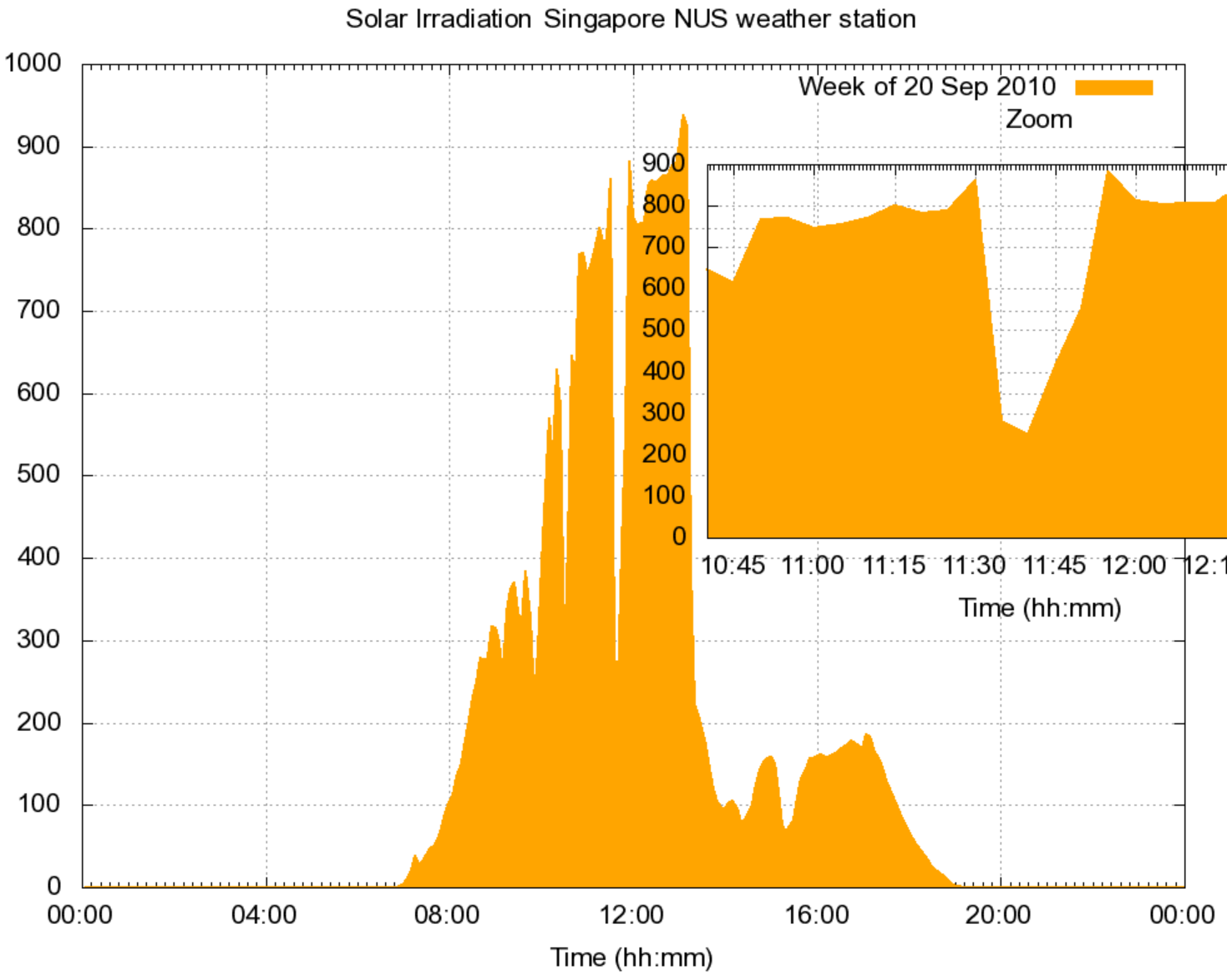
HOW DOES HIGH RENEWABLE ENERGY PENETRATION IMPACT THE GRID

Uncertainty: There is a difference between the actual value and the predicted value

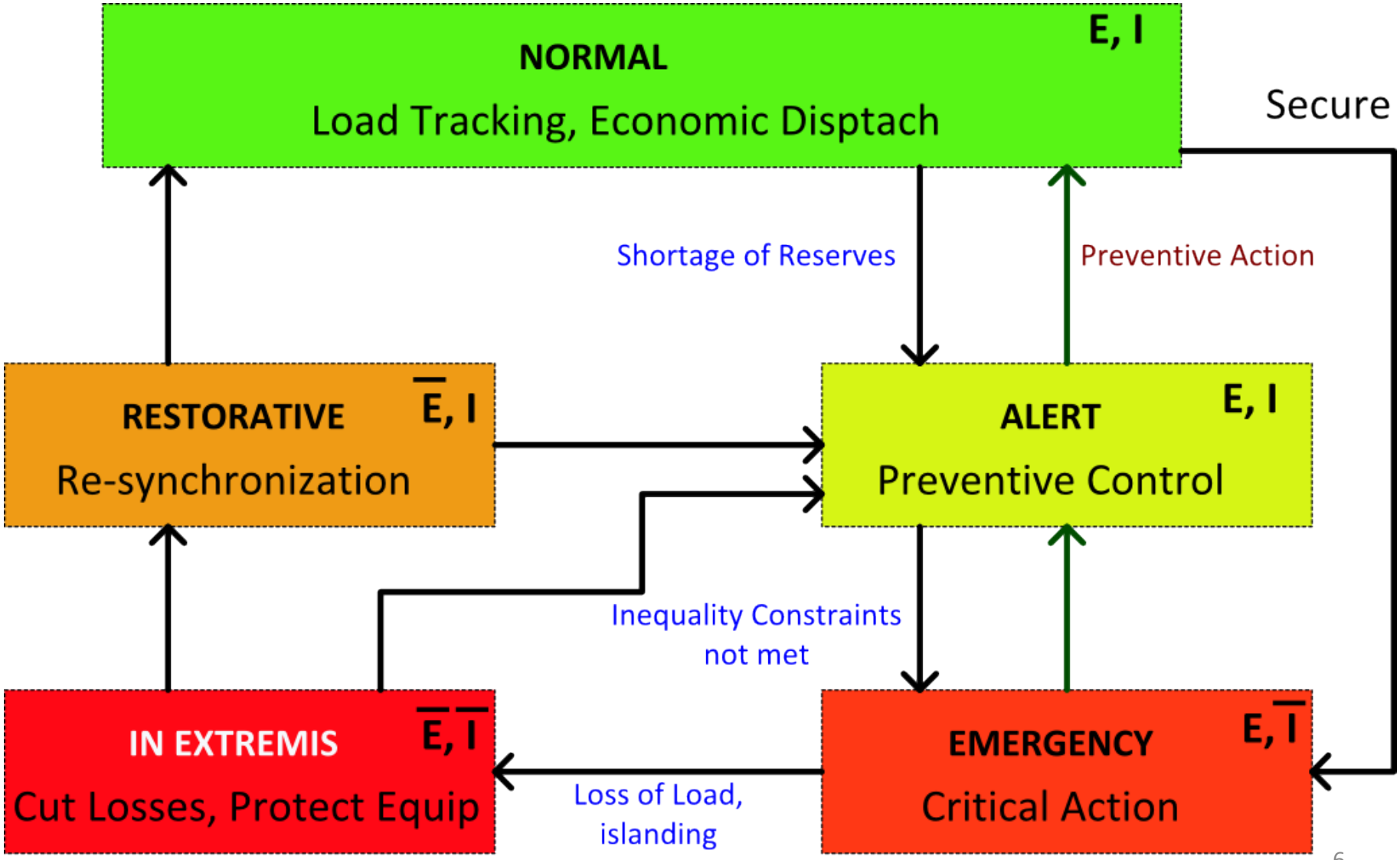


Renewables from Solar PV is variable – to counter variability we need other sources

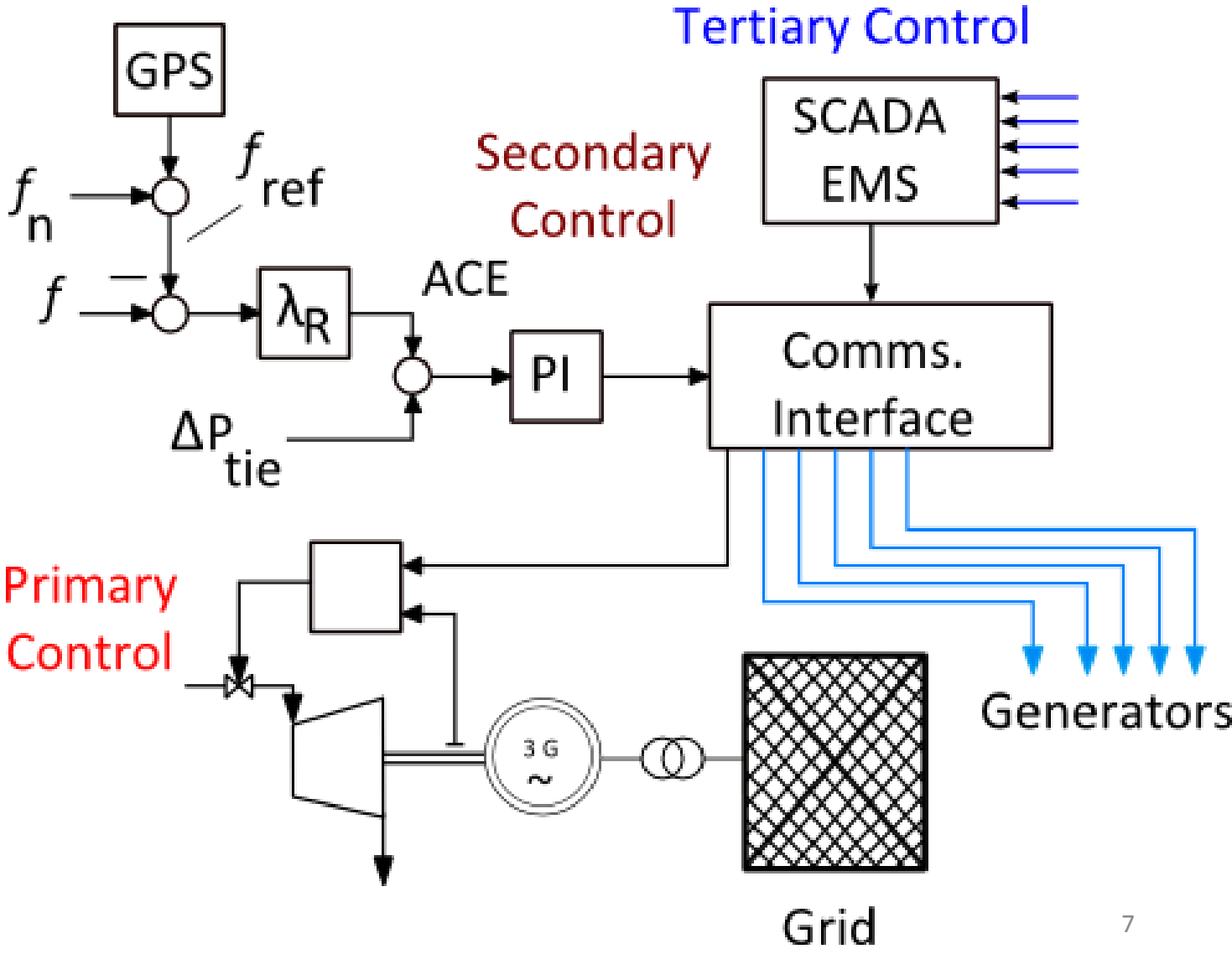


HOW DOES IT AFFECT GRID STABILITY?

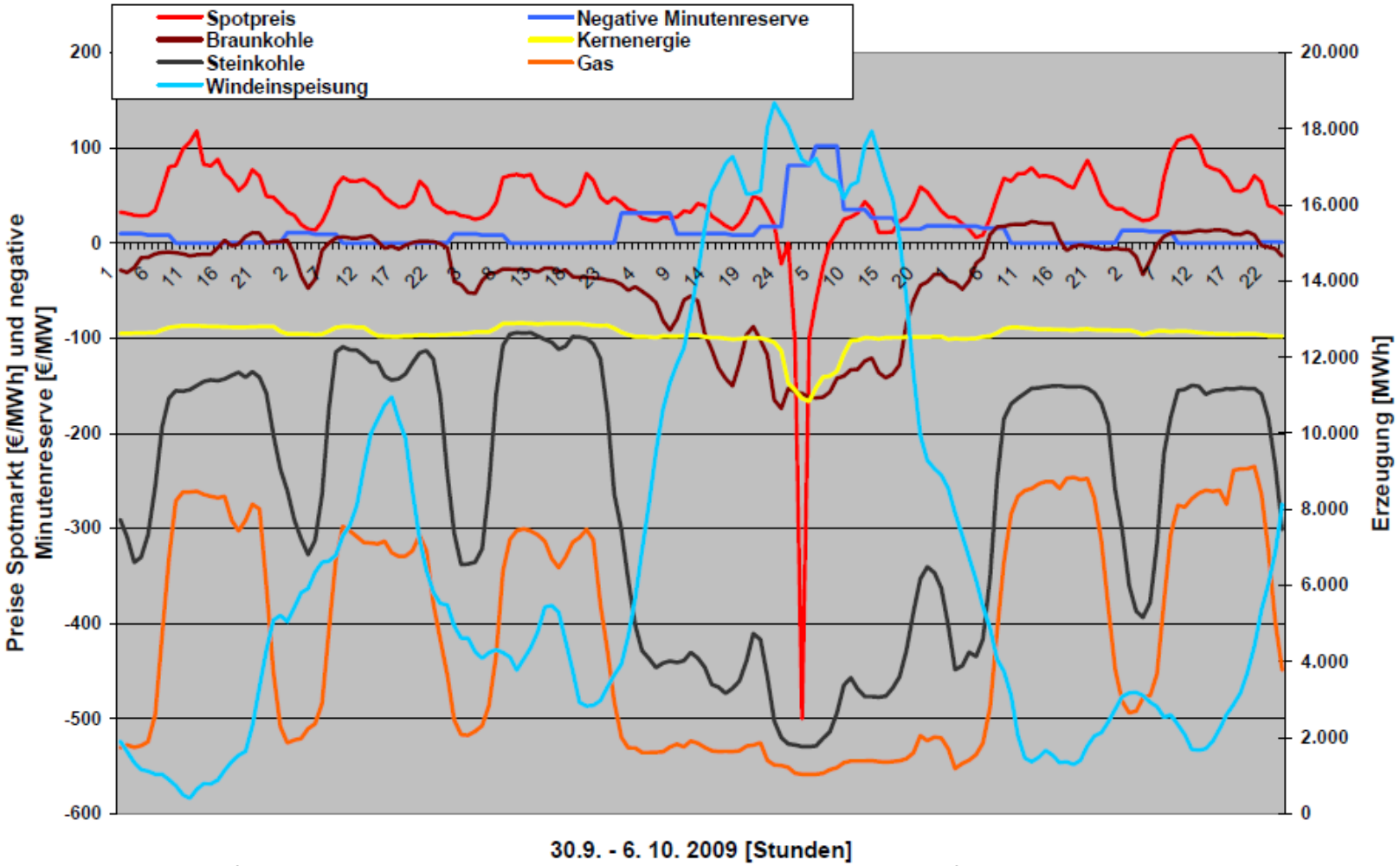
Classification of Power Systems operating states based on CIGRE Rep. No 325



Control of Grid Frequency has three layers

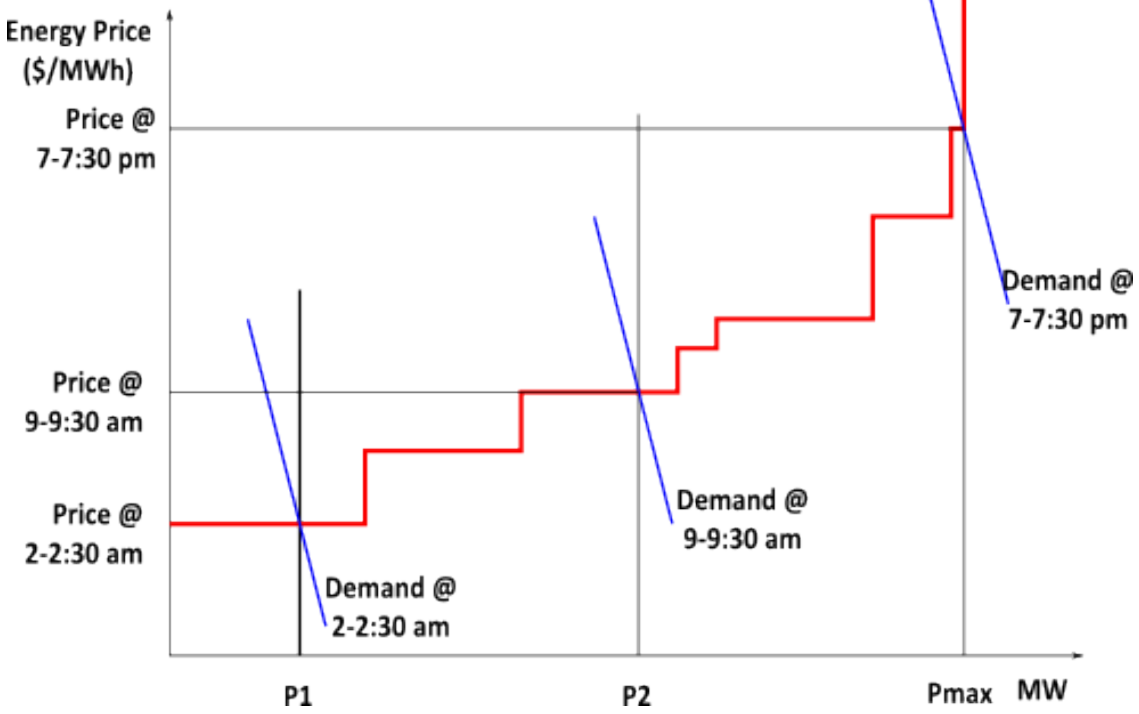


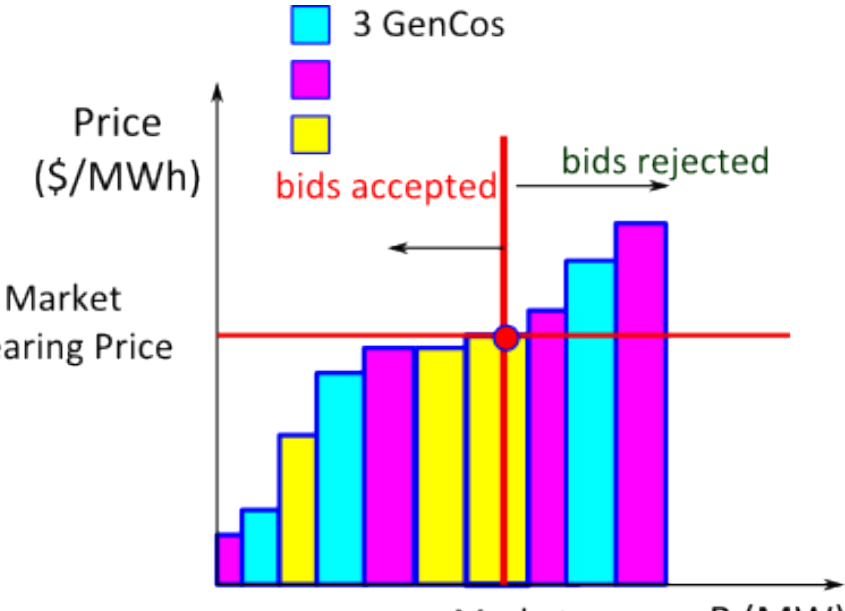
What to do in case of surplus? Case of negative spot price 3-4 October 2009 in Germany



Analyse der Ursachen fuer negative Strompreise am 3-4 Oktober 2009 und moeglicher Abhilfemassnahmen
Studie im Auftrag des Bundesministeriums fuer Wirtschaft und Technologie, EWI and der Uni Koeln

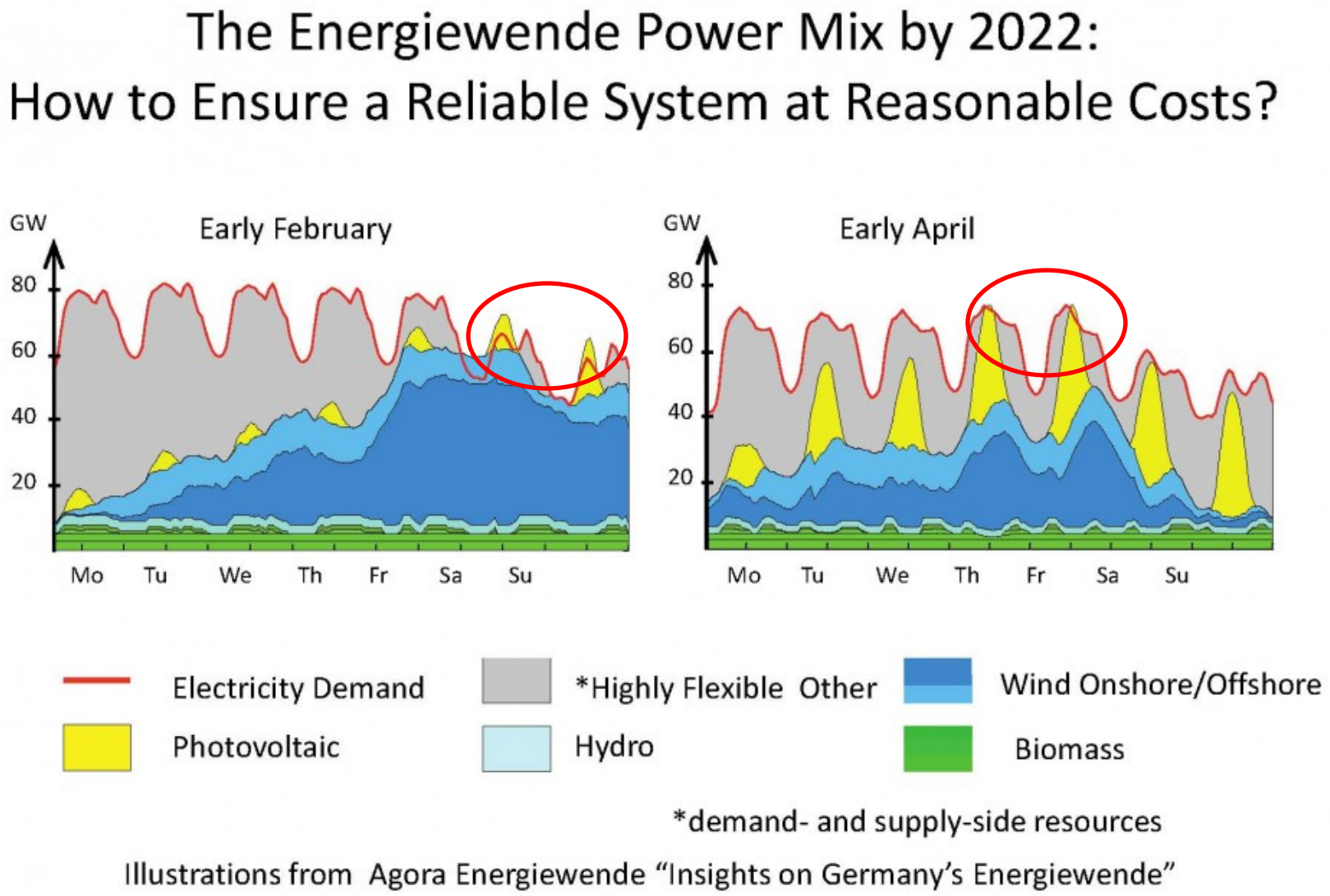
Market Dynamics influences the actual power flow in the system





How to maintain stability?

Surplus Power from Renewables and Global stability reflects in fall in price….or curtailment….=Storage?



http://www.raponline.org/featured-work/making-germanys-energiewende-energy-transition-a

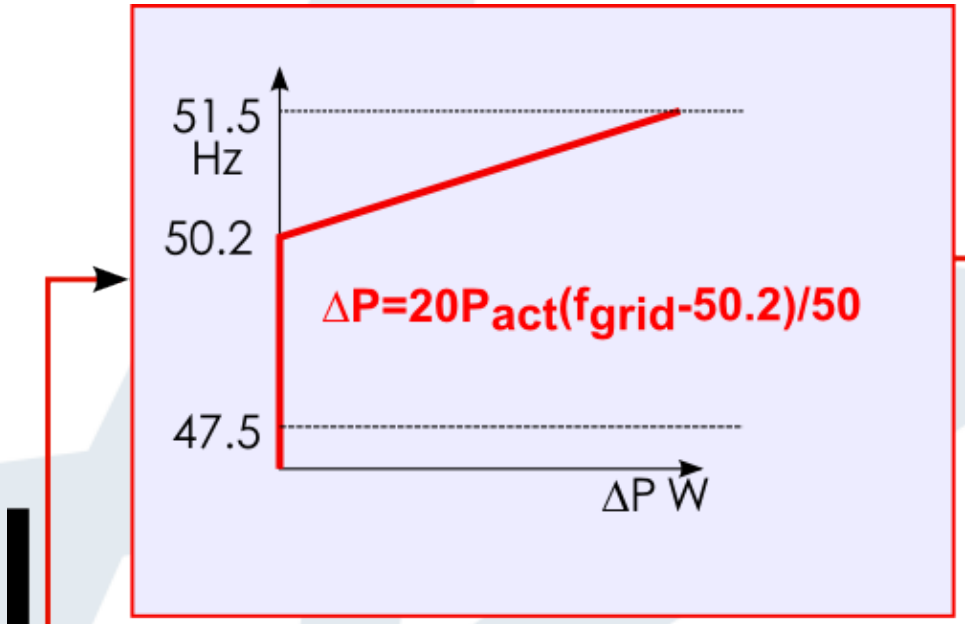
Fast change in power dP/dt due to high penetration of renewables

Germany 50% penetration needs 6 GW in 15 mins

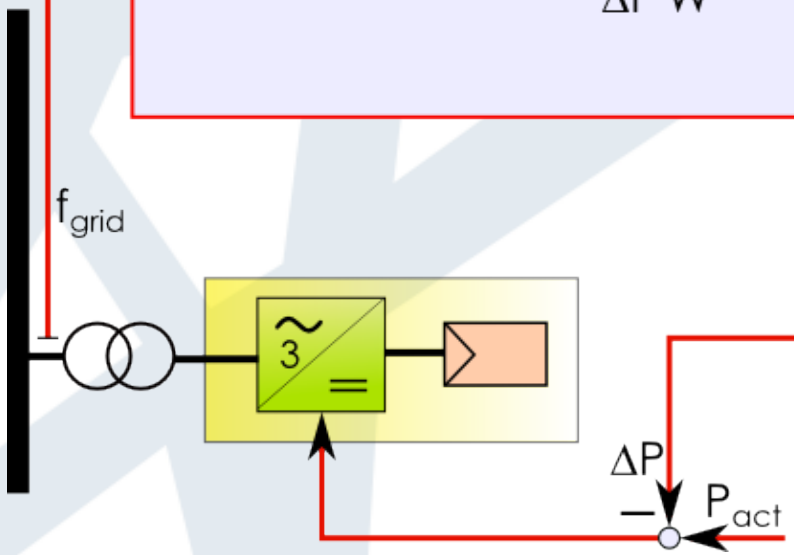
Rates will depend on the penetration and nature or irradiation

	Capacity	Coal	CCPP	GT
Minimum Load	MW	400	500	500
P change in 5 min	MW	50	100	400
Start-up Cold	h	10	4	<0.1

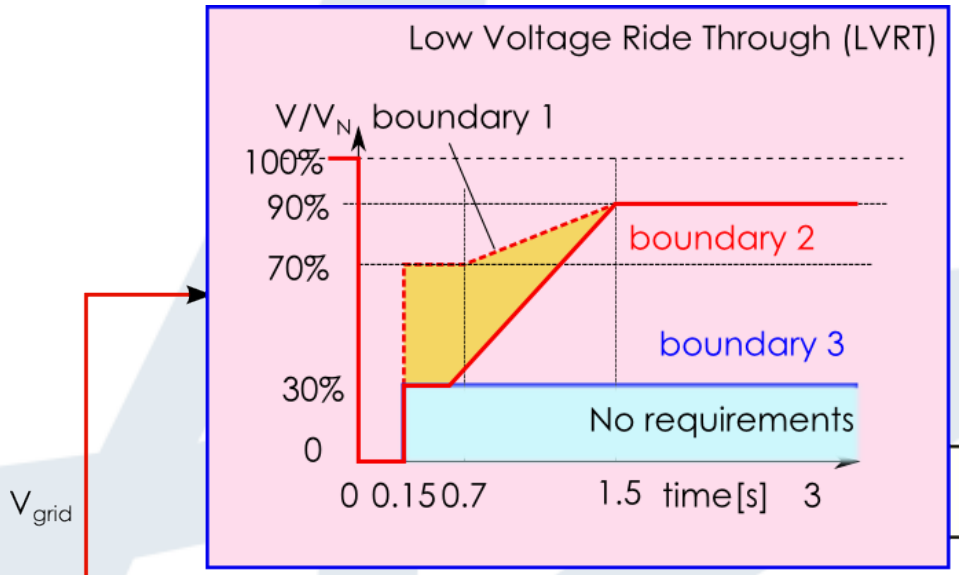
DER inverters at MV level need to have active power reduction at over frequency (1 Jul 2010)



Disconnect for
$f_{grid} \leq 47.5$ Hz
or
$f_{grid} \geq 51.5$ Hz



Low Voltage Ride through requirement for MV connected Distributed Generators



If V is above boundary 1
remain connected

no

ask permission
before shut down

yes

Resynch
< 2s

no permission

remain connected
above **boundary 2**

V_{grid}

PV Generator

ON

Turn off

LVRT
Control

If V is below **boundary 3**
then shut down

+ reactive current
100% of nominal current within 20ms

THE LOCAL BOTTLENECK

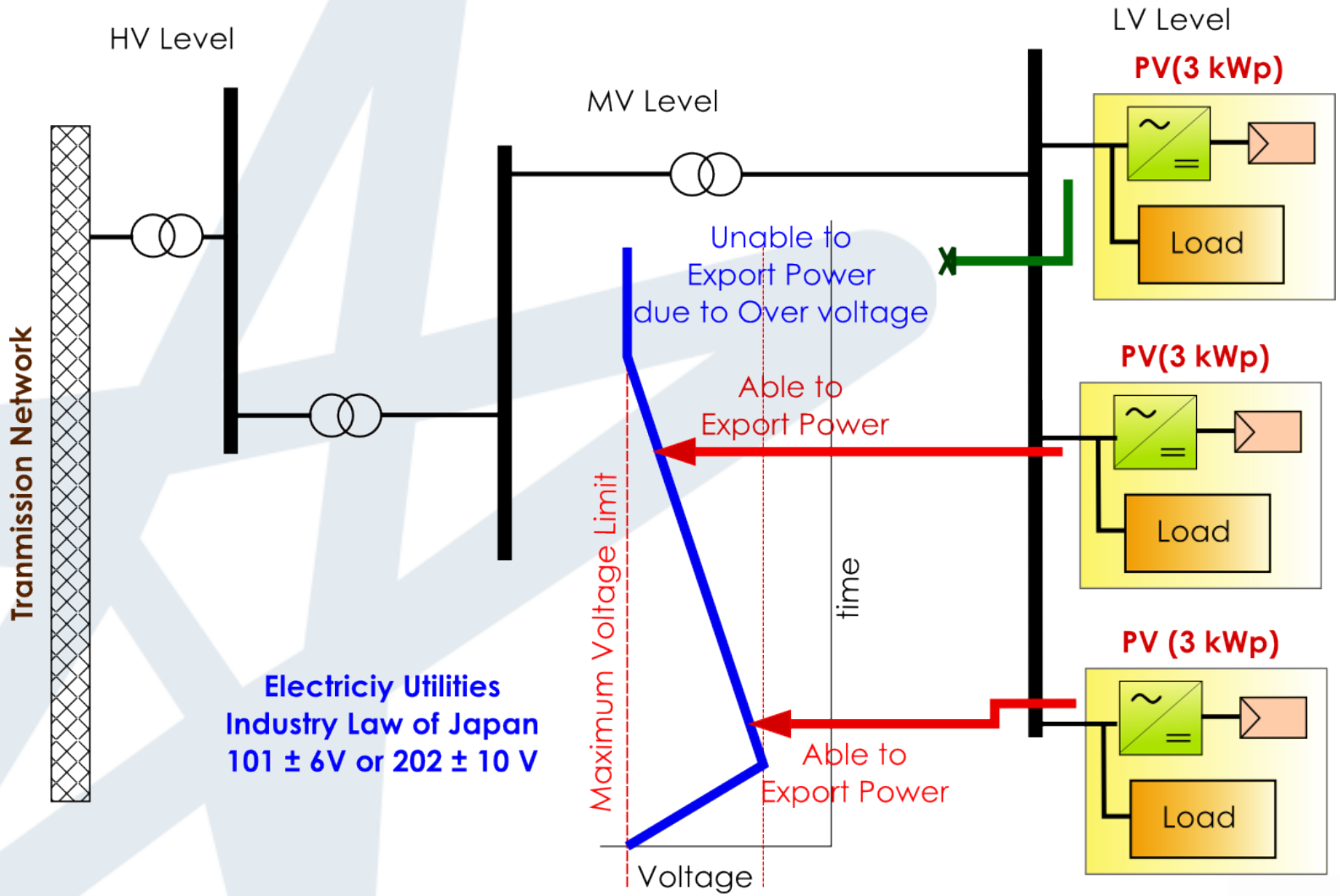
Local problems: Ota Project in Japan funded by NEDO

http://www.pvdatabase.org/urban_view_details.php?ID=32

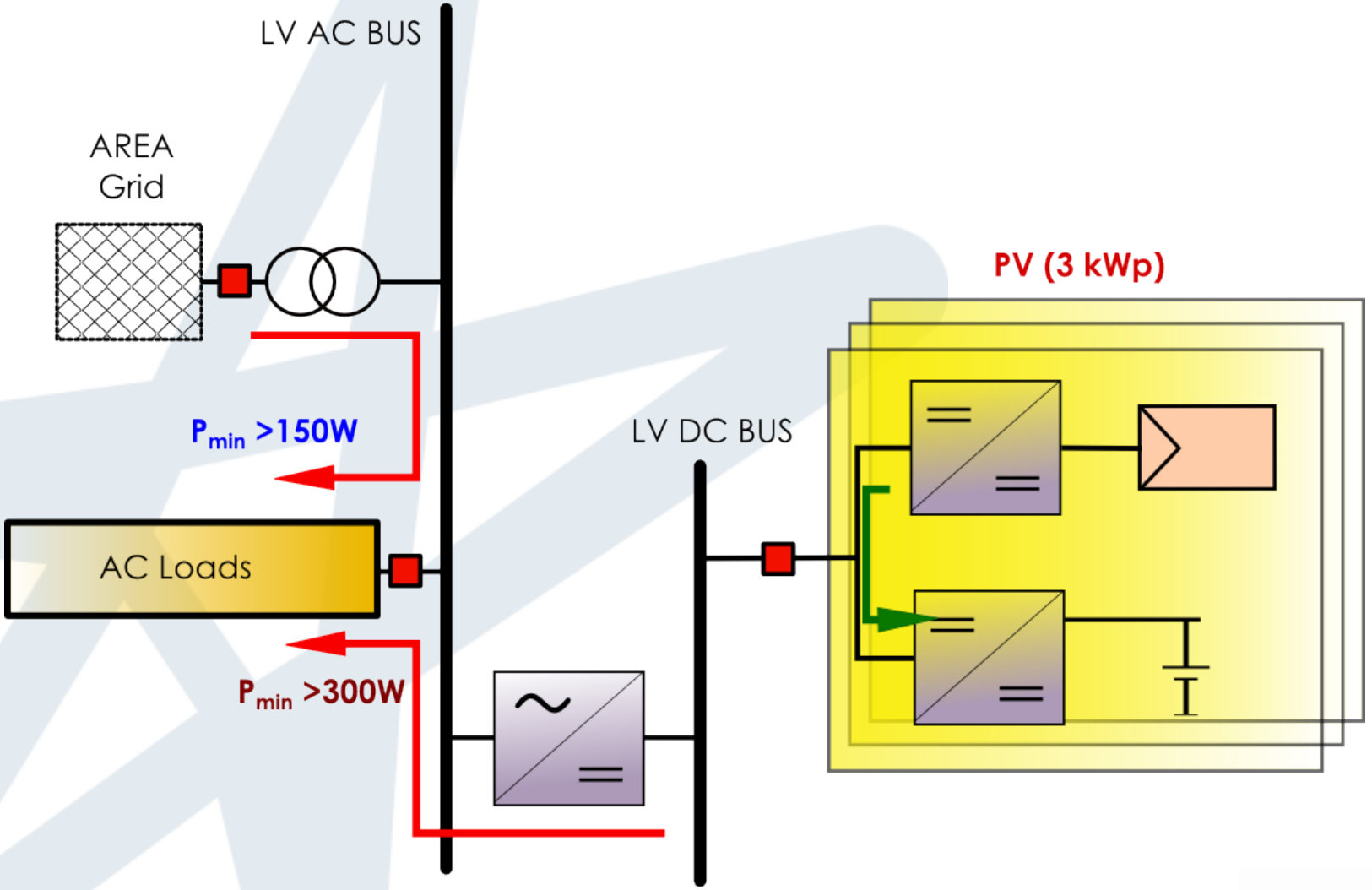
Pal Town Josai-no-Mori , Ota Japan Latitude 3618’32’’N

2160kWp Inclined Roof Top, Flat Roof Mechanically fixed
Project Lead: Kandenko CO Ltd & NEDO, Units 553 PV power per unit 3kWp
Operation 2006

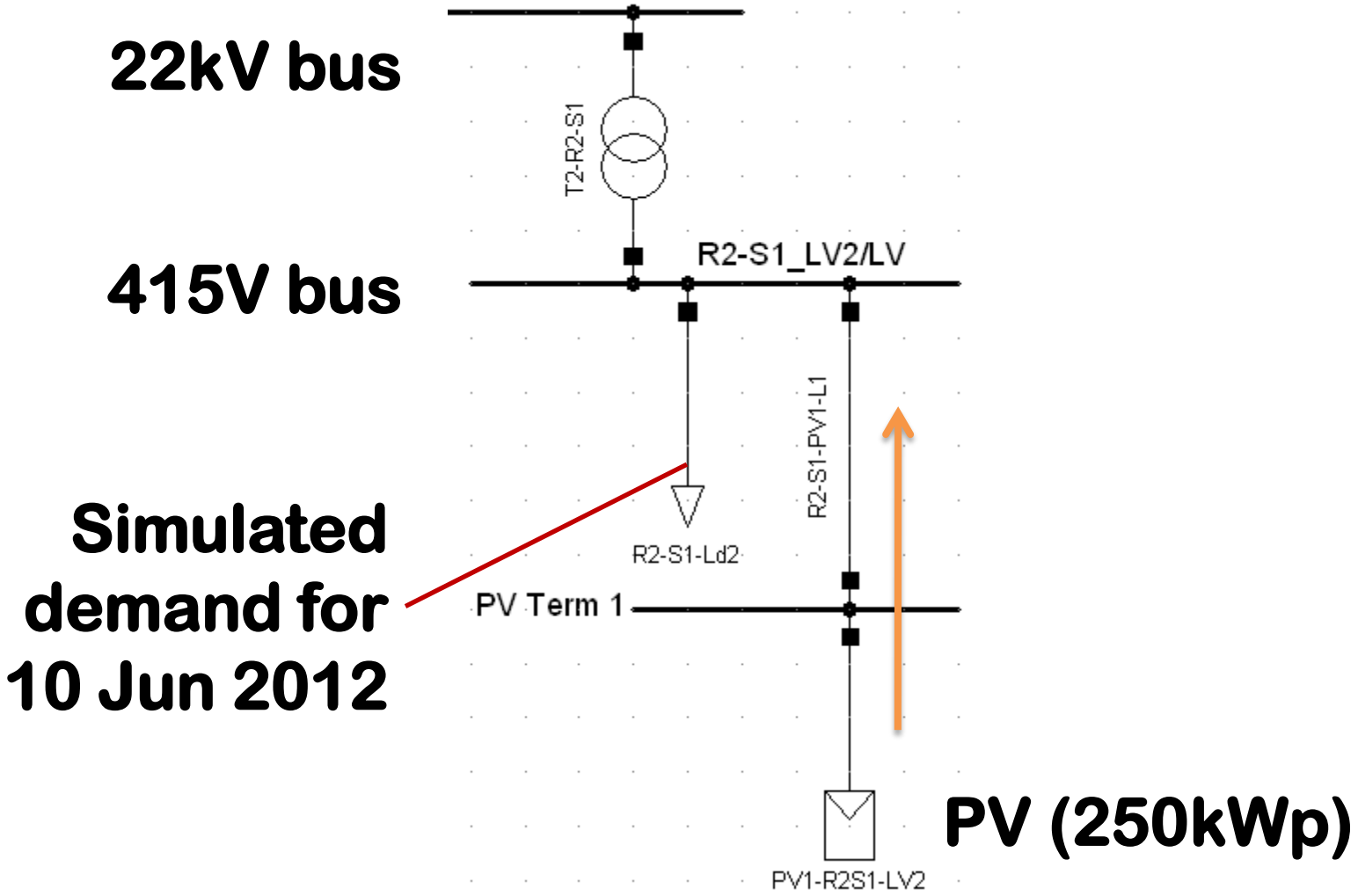
Excessive Power Export increases Voltage causing power export limitation



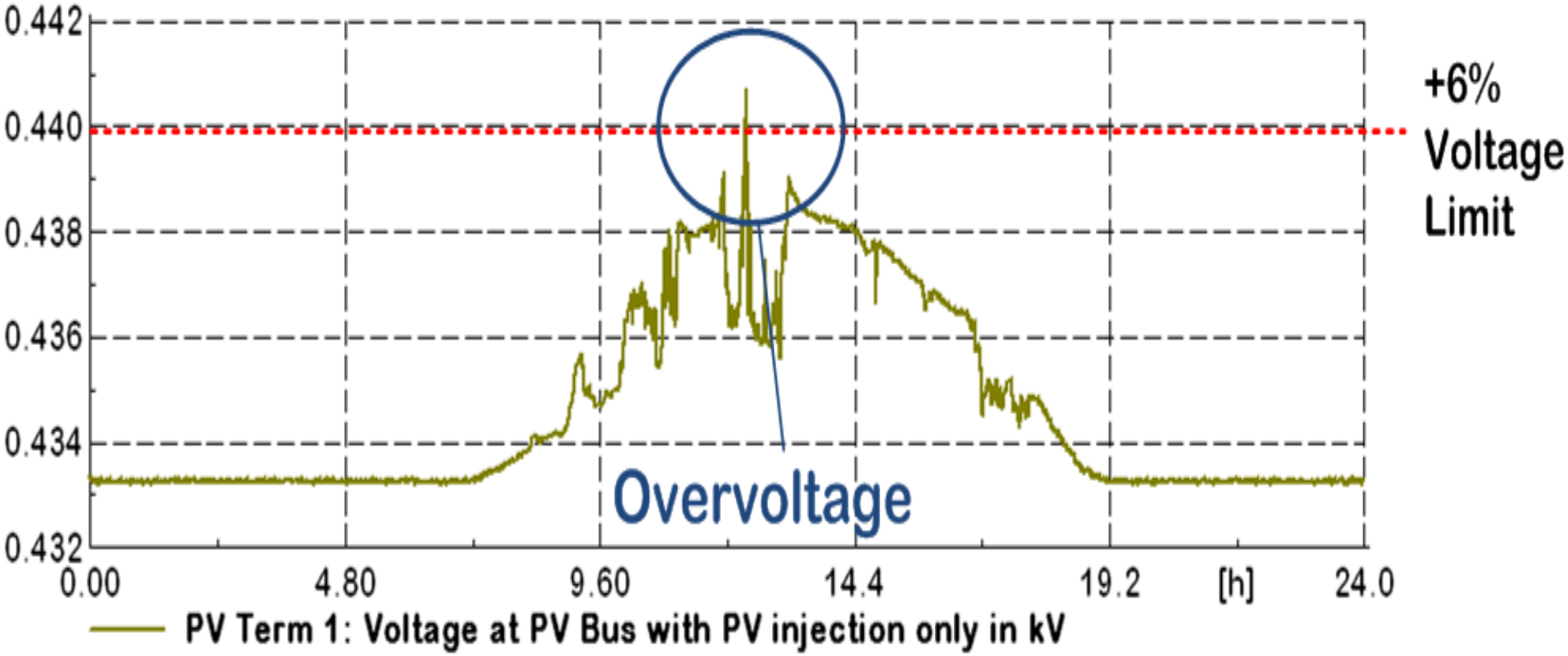
Each unit has Battery storage and Export power to the Grid



Voltage rise during PV power Generation: Voltage for 10 Jun 2012



Voltage variation at PV Bus over 24 hours

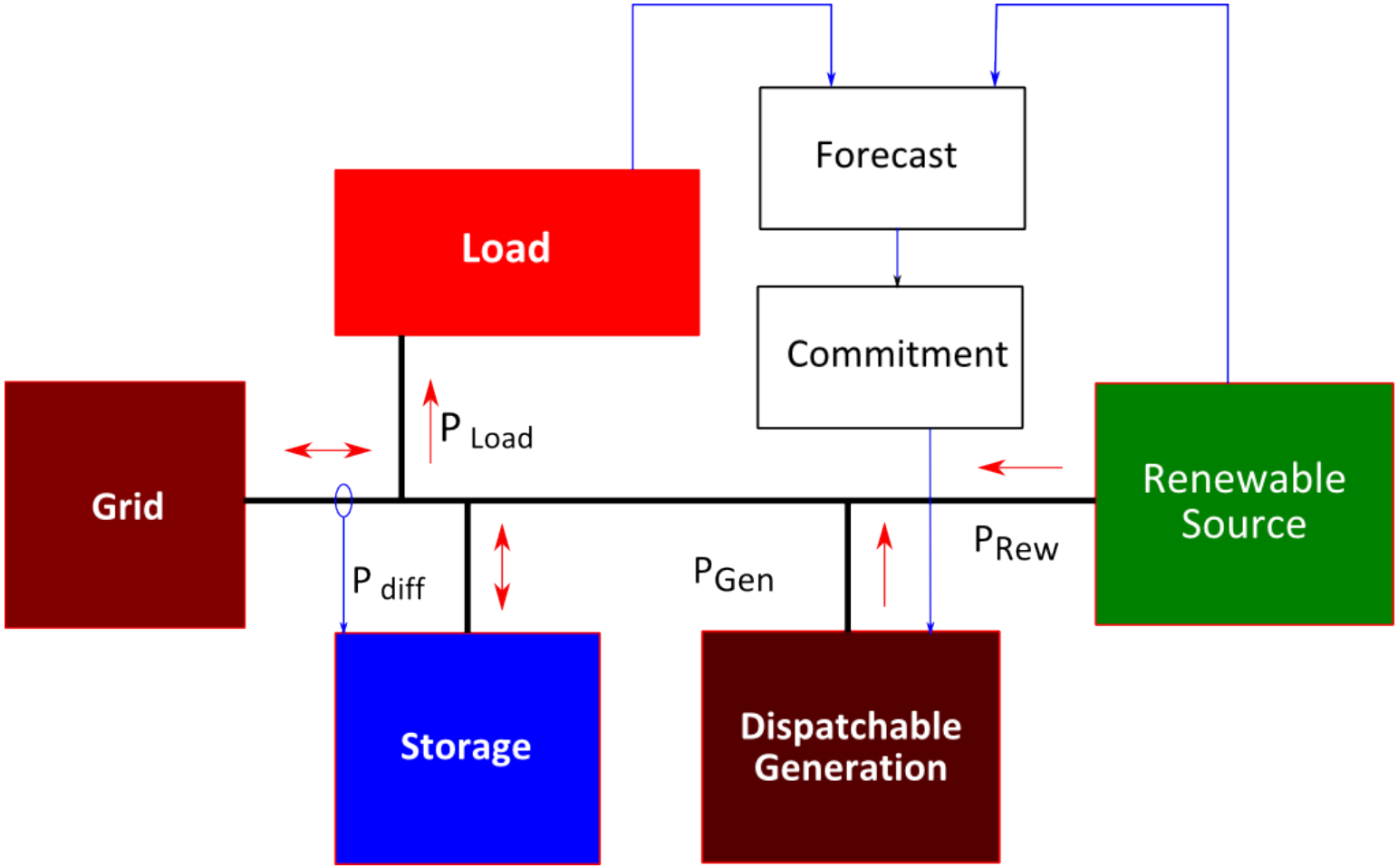


During low loading conditions, high PV production may cause overvoltage to occur.

Why do we need Energy Storage

- Renewable Integration problems
  - Seasonal: will occur when penetration is very large
  - Load following: Fast changing response needed
  - Intermittency: Short term storage
- Power Quality problems: small capacity
- Transmission network problems – congestion and frequency regulation

Storage as load balancing resource



EPGC enables test-bedding of research at close to power grid conditions

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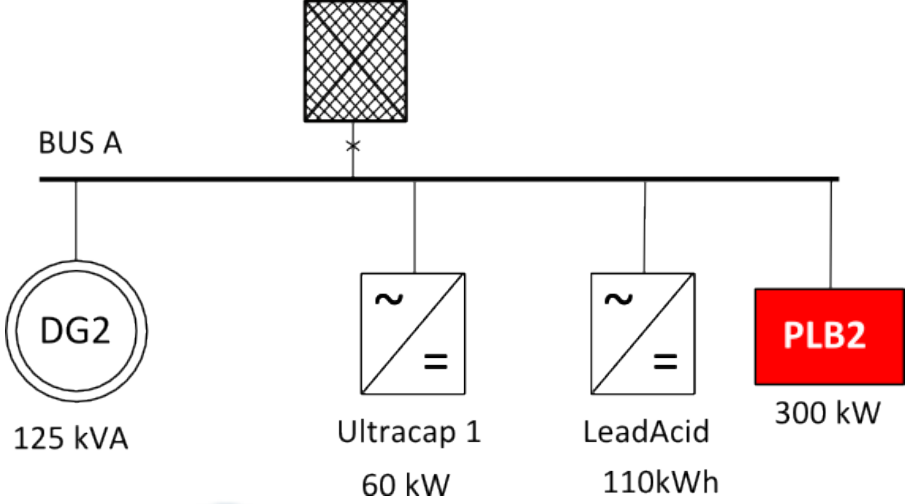
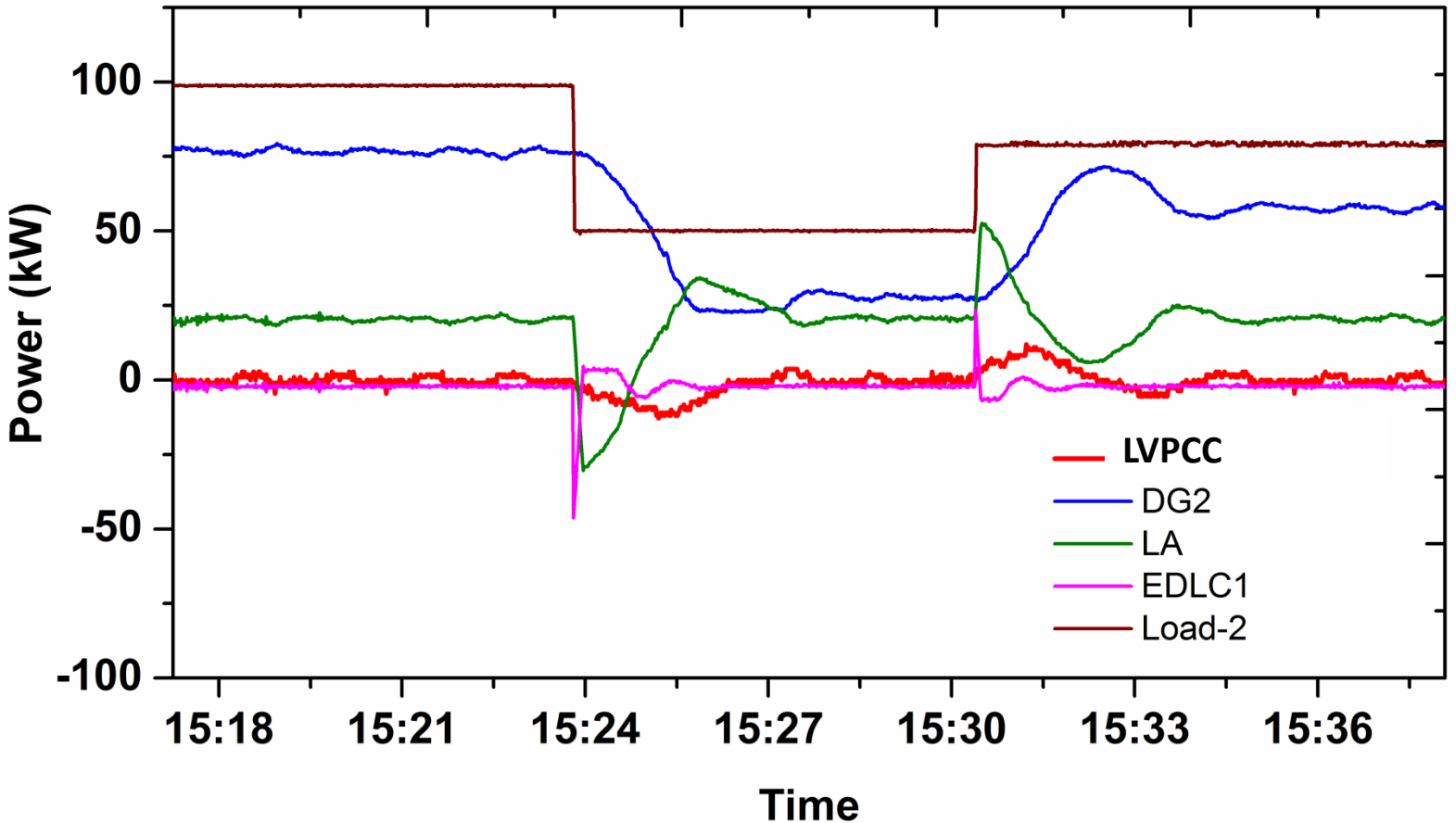
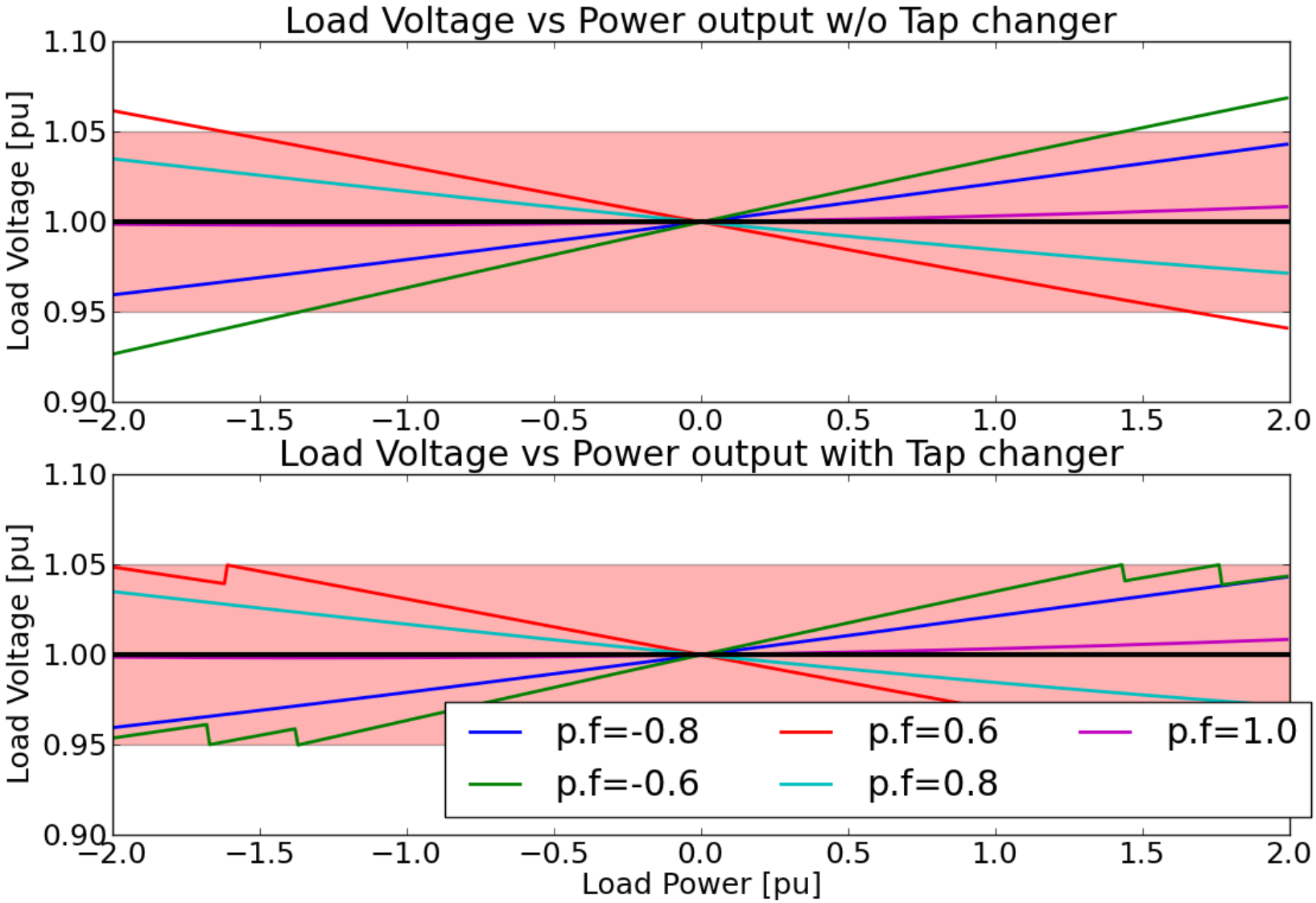
Ultracapcitor is being used to compensate faster dynamics





Voltage variation at the sending end can become greater than the limits

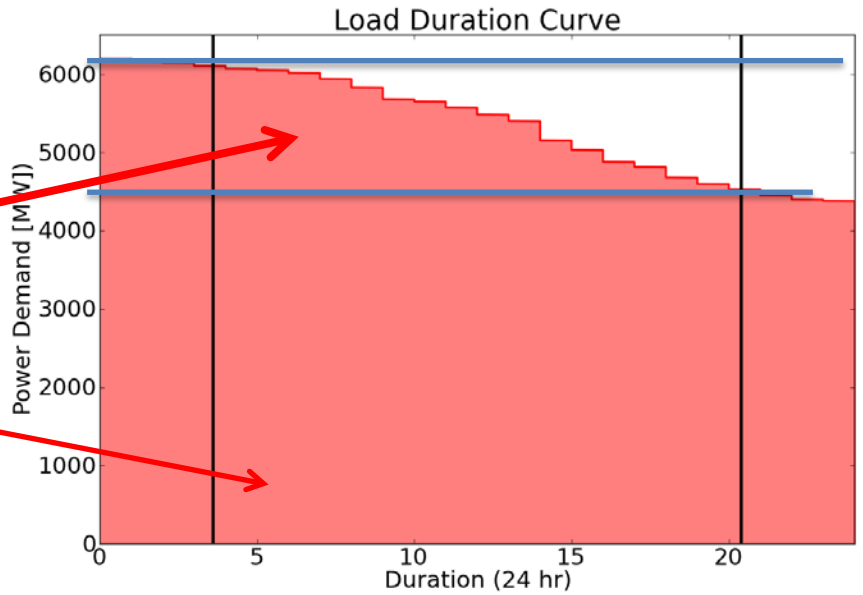


WHAT TYPE OF STORAGE DO WE USE?

There are three time duration ranges energy storage can perform – Grid

Power [MW]	Time	Energy	Function
10 - 1000	1 – 8 hrs	10-8000 MWh	Spinning Reserve
0.1-2	0.5-4 hrs	5kWh-8MWh	Peak Shaving, Deferral
0.1-2	1-30 sec	0.03-20kWh	Power Quality

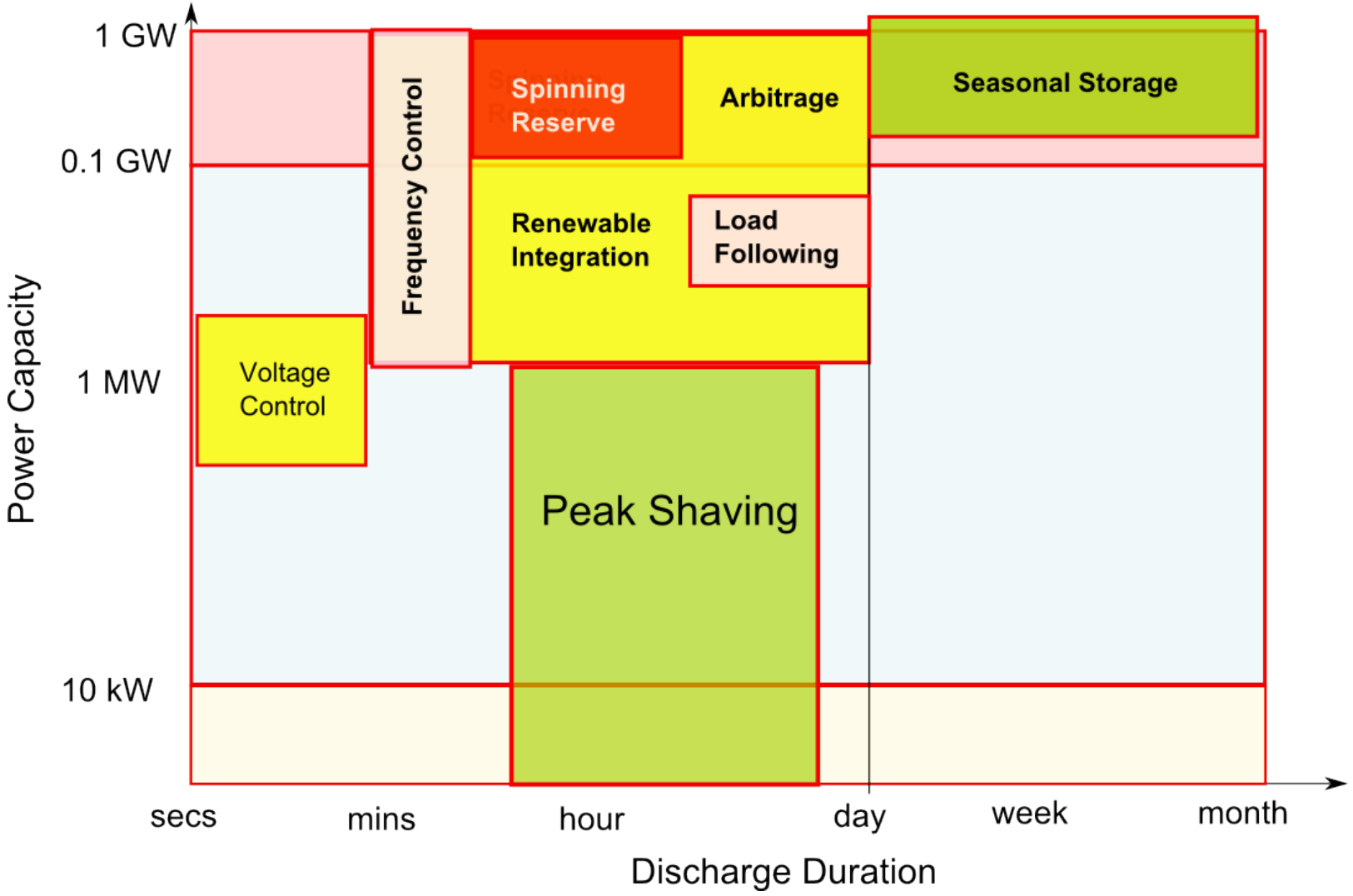
- Peaking plants
- Mid-merit plants
- Base plant operation



Impact of storage and wind in Europe scenario

- Size of storage has an impact on merit order of plants
- Small storage size increases base plant input and reduces mid-merit plants operation
- Large storage size reduces base plant contribution and increases mid-merit plant operation
- Revenues generated can support profitability, cost of storage is very high at present.
- The price ratio between peak and off peak should be large enough to generate profits

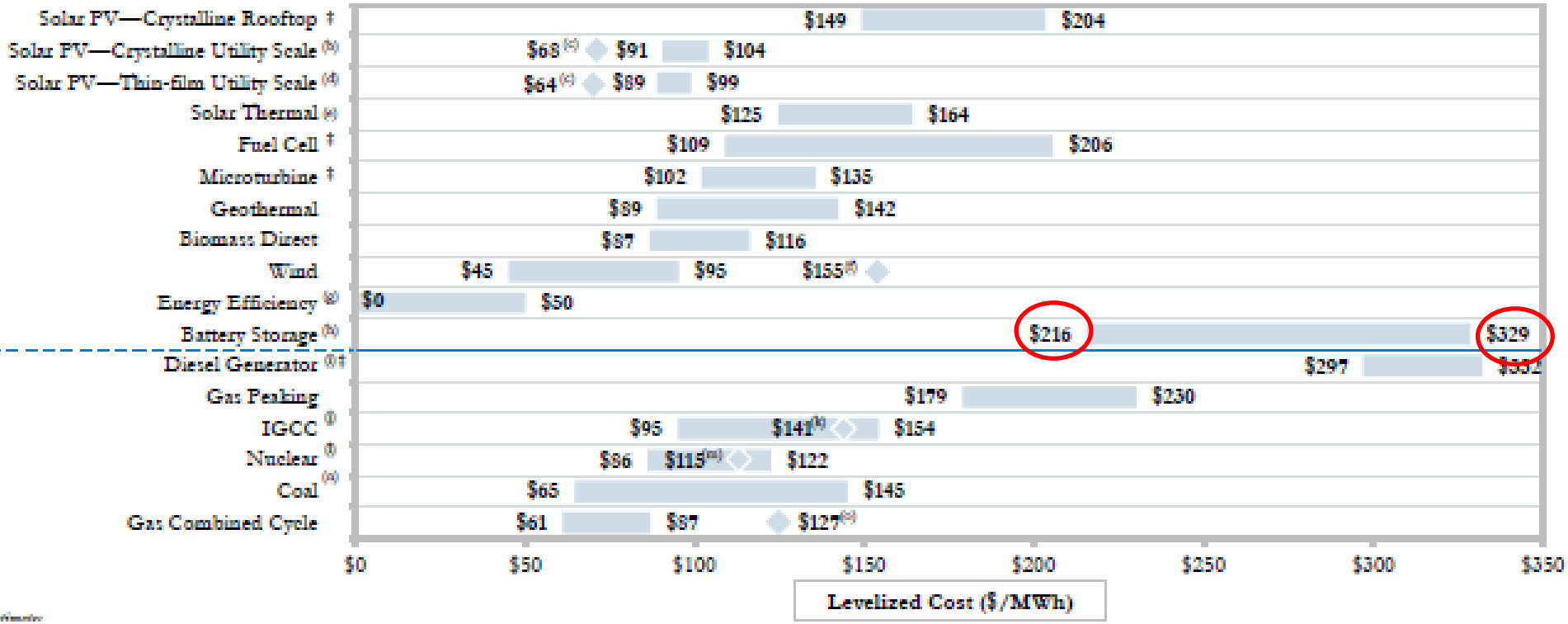
Energy Storage Functions and their characteristics



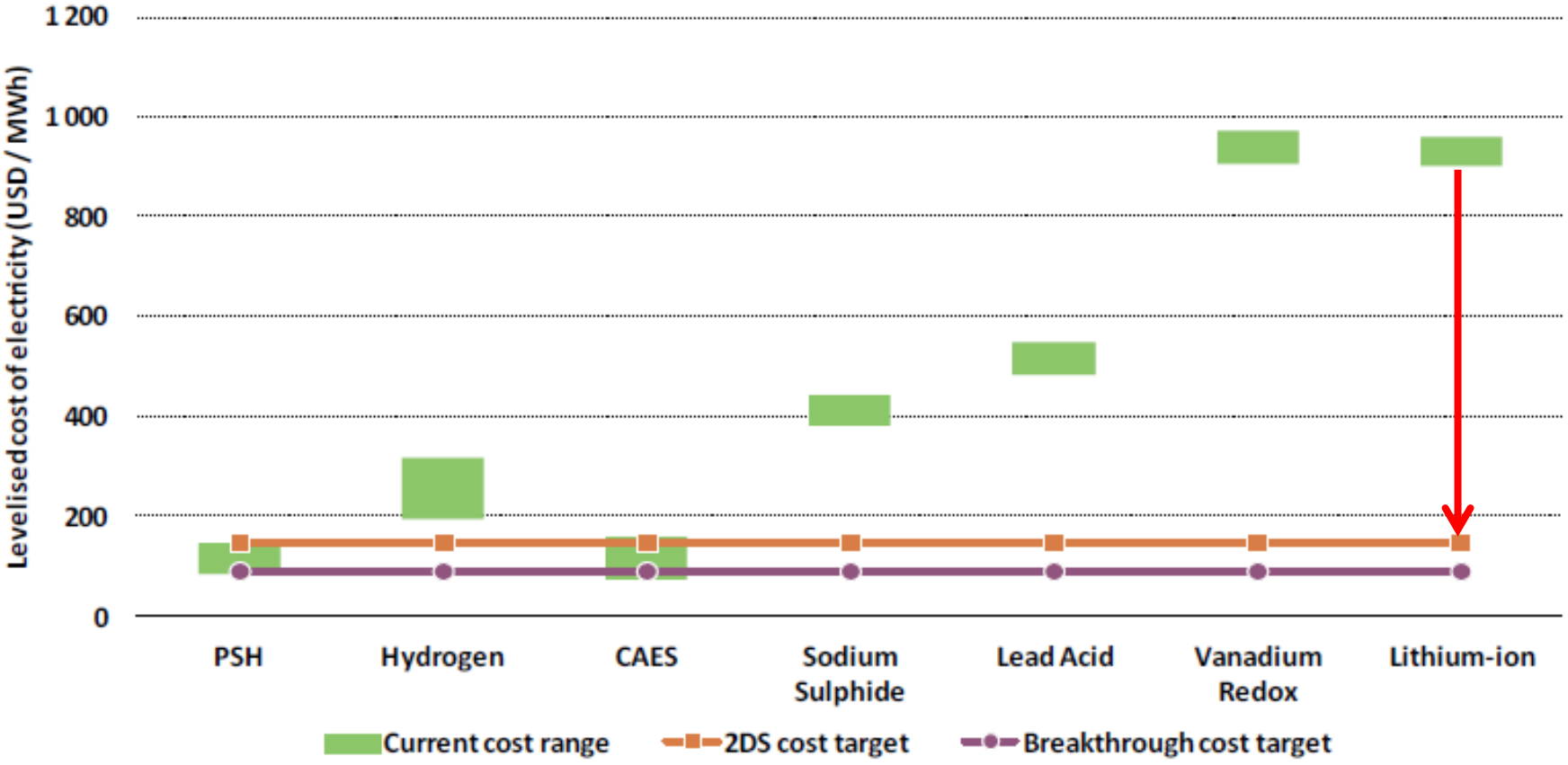
How Can Storage be used for Grid Applications

SUMMARY

Cost of some of the technologies is high



IEA Roadmap says steep decrease in prices is needed, But we need Reliability and Security



Technology Roadmap Energy storage IEA, 2015

Some References

- The viability of balancing wind generation with large scale energy storage: Batsaikhan Nyamdash , EleanorDenny , MarkO'Malley: Energy Policy 38 (2010) 7200–7208
- 12 Insights on Germany's *Energiewende* "12 Thesen zur Energiewende. Ein Diskussionsbeitrag zu den Herausforderungen im Strommarkt", Agora Energiewende 2012 (original: German language).
- IEA Technology Roadmap Energy Storage 2015
- State-of-the-art electricity storage systems Indispensable elements of the energy revolution Josef Auer josef.auer@db.com, DB research, www.dbresearch.com