Smart Grid to accommodate more renewables

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Structure of talk

- Future power system in Sri Lanka
- Renewable potential
- Operational issues with renewables
- Solutions through Smart Grid

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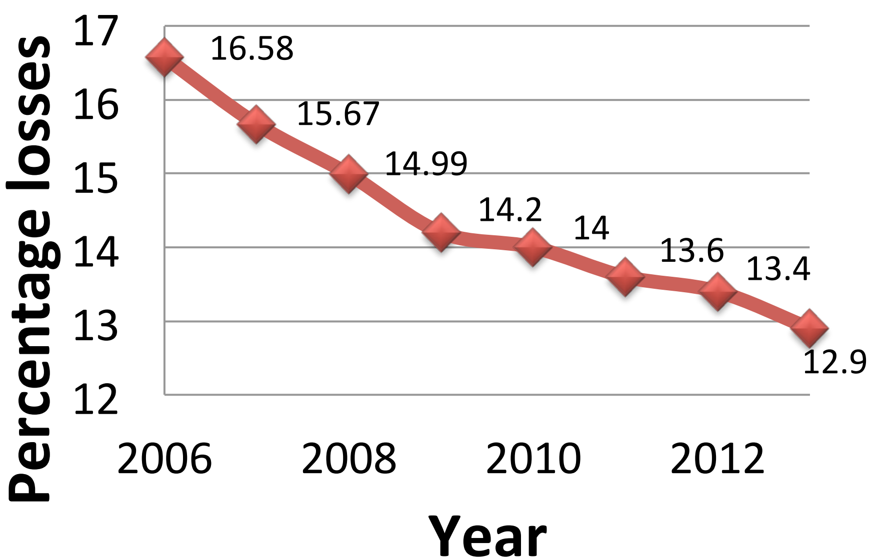
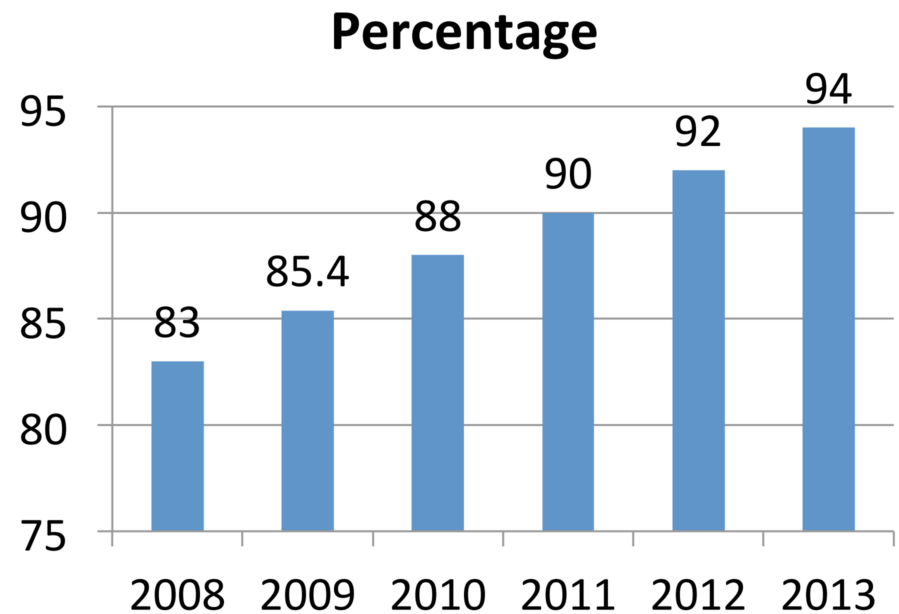
IR3S

Positive trends

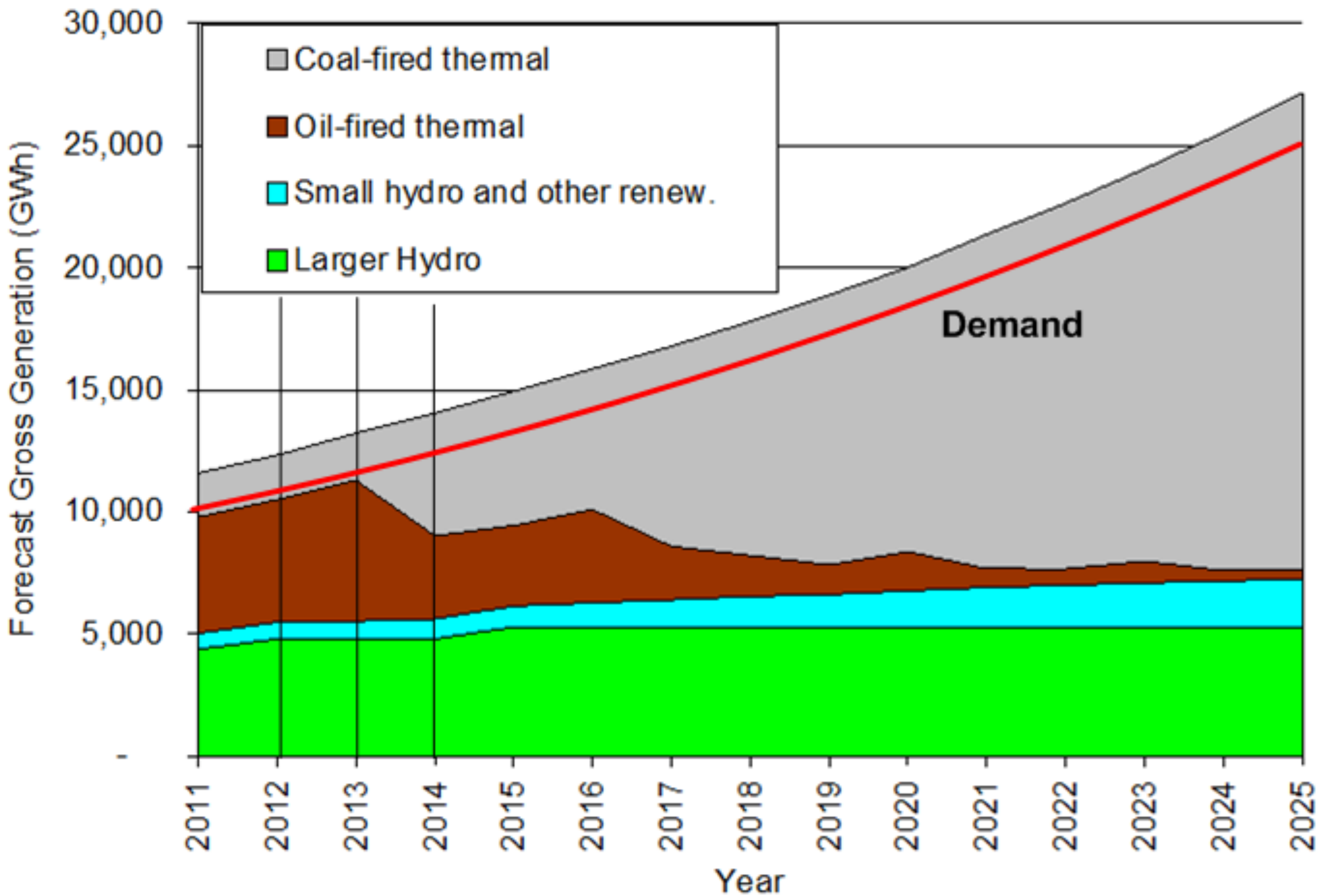


System losses are coming down



Household electrified is increasing

Generation projections



This reflects the national policy target of 10% by 2015, and retains approximately the 10% share into the future

Total Cost of Production and Delivery of Electricity: 2013 (and estimate for 2014)

2013

Primary Source	**Ownership**	**Share**	**Cost Rs/unit**
Hydro	CEB	30%	-
Small Renewables	Private	7%	18.00
Coal	CEB	15%	8.30
Oil	CEB and Private	48%	23.41
Average		100%	**13.74**

		Rs/unit
Generation	Capacity	2.75
	Fuel	13.74
Transmission		0.77
Distribution		2.72
Network Loss Adjustment		1.82
Short-term Debt repayment		0.32
Total cost		**22.12**

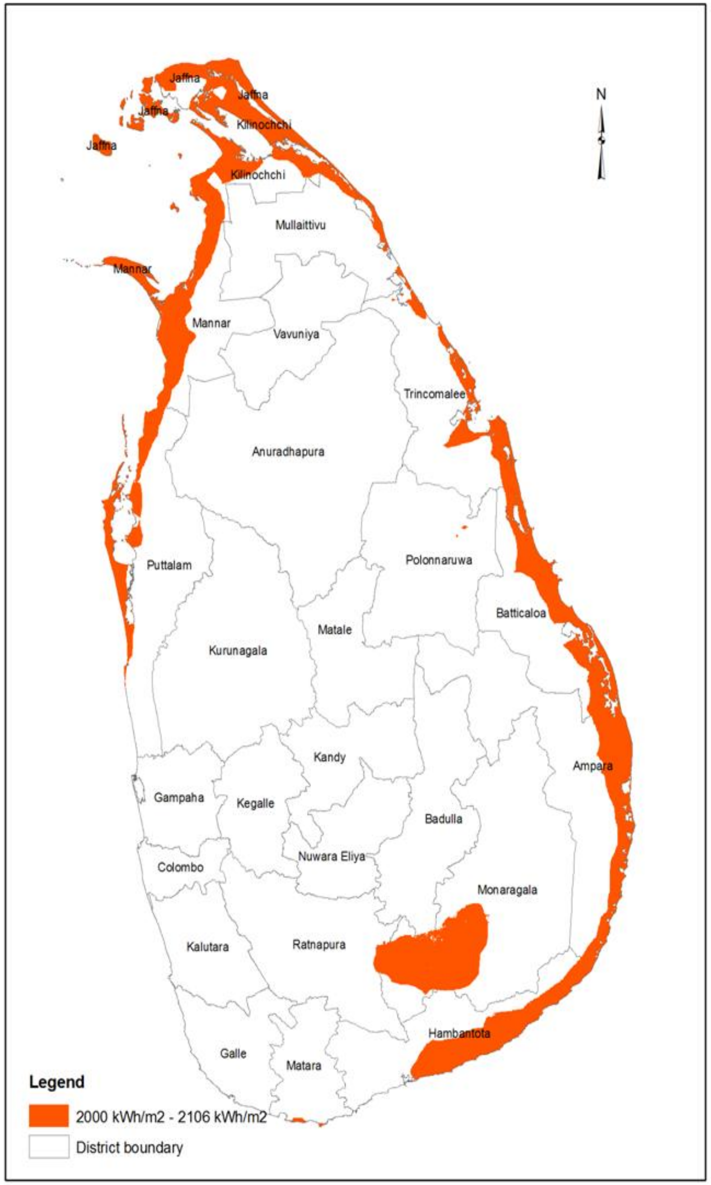
2014

Primary Source	**Ownership**	**Share**	**Cost Rs/unit**
Hydro	CEB	30%	-
Small Renewables	Private	7%	18.00
Coal	CEB	45%	8.50
Oil	CEB and Private	18%	23.41
Average		100%	**9.30**

Generation	Capacity	2.50
	Fuel	9.30
Transmission		0.77
Distribution		2.72
Network Loss Adjustment		1.27
Short-term Debt repayment		0.32
		16.87

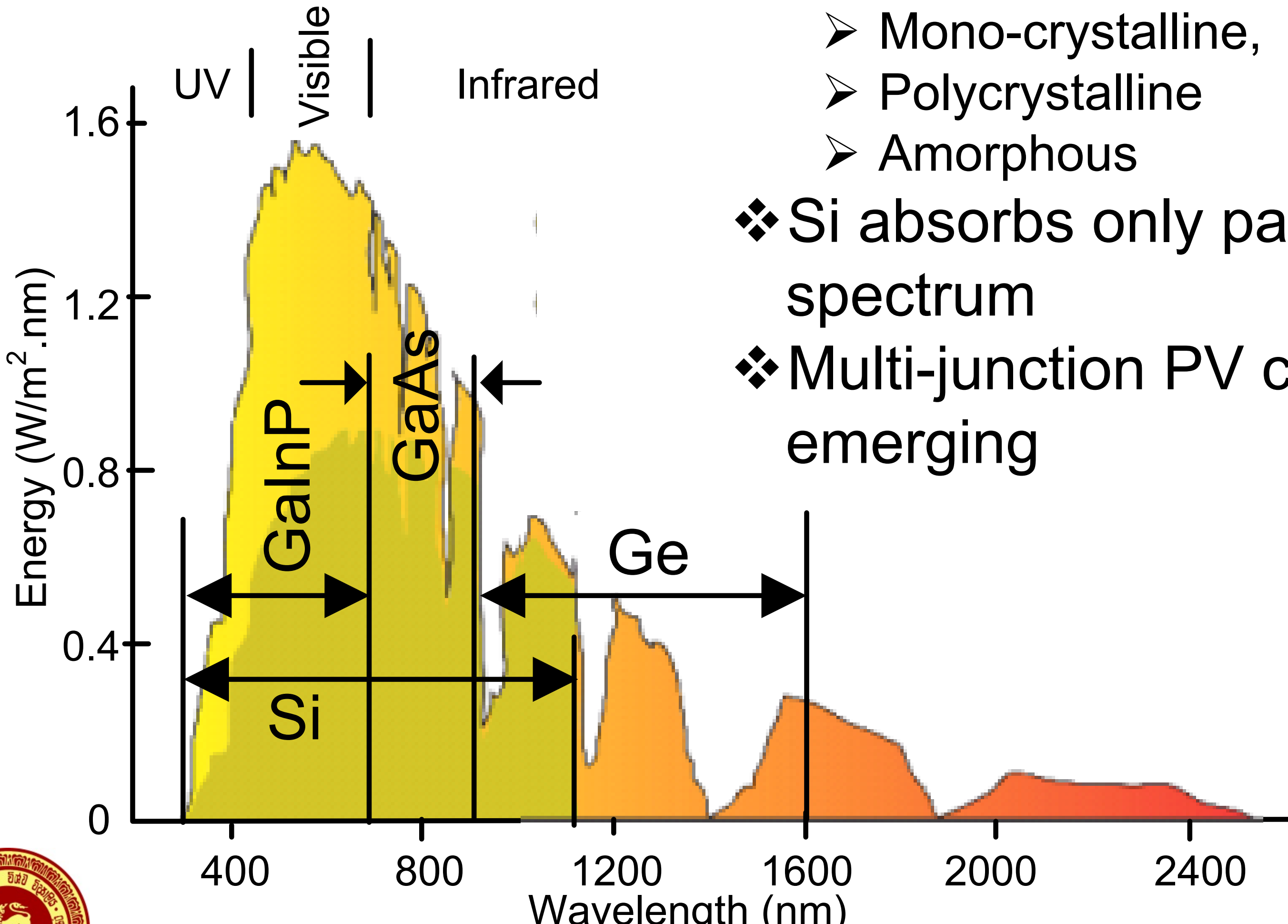
Renewable potential in Sri Lanka

PV potential in Sri Lanka



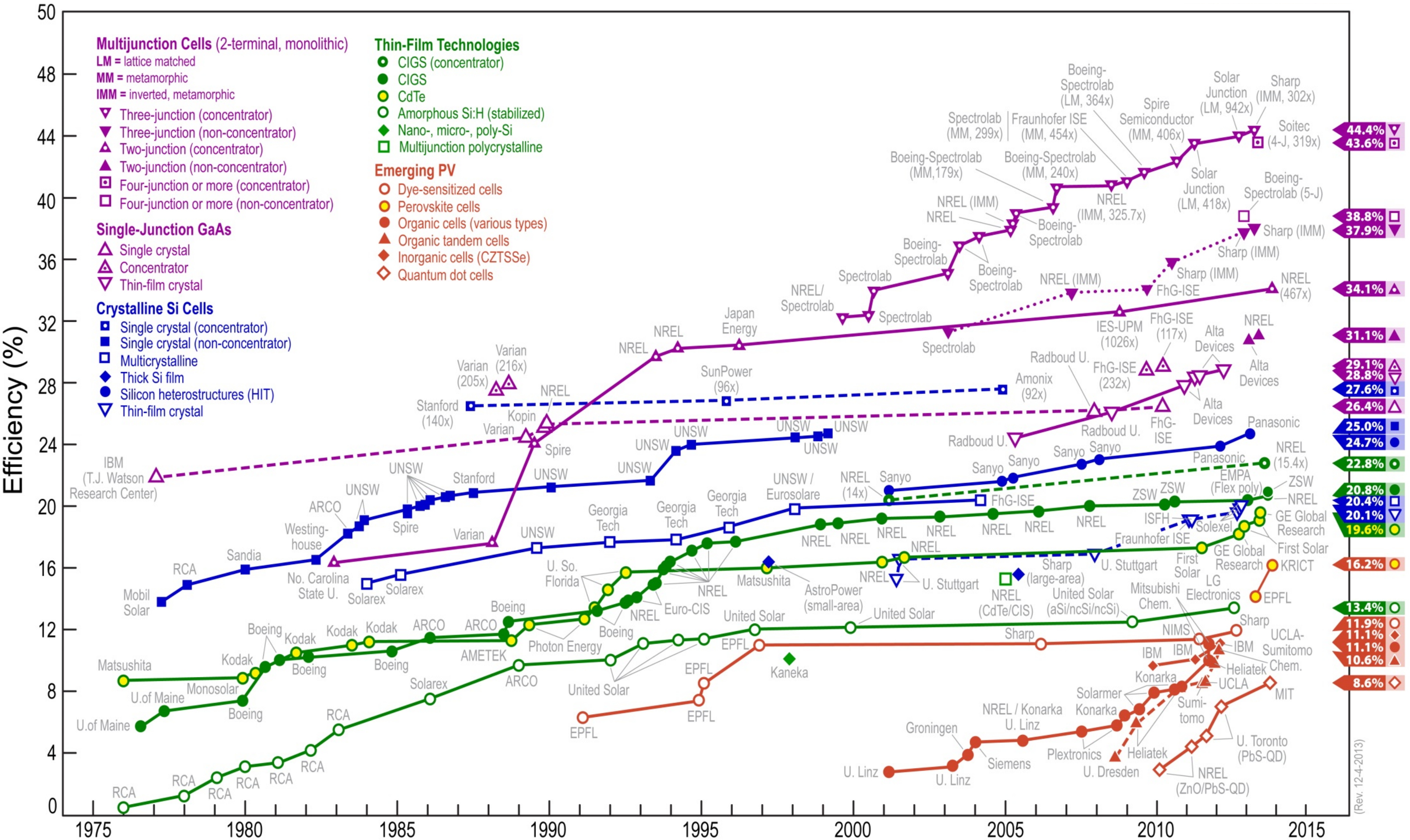
- Regions with horizontal Irradiance > 2000 kWh/m^2/year
- Solar power developments
  - Roof-top solar PV systems operating in net metering mode
  - Large-scale centralized solar PV plants

PV Technologies



- ❖ Most of the technologies are Si based
  - ➢ Mono-crystalline,
  - ➢ Polycrystalline
  - ➢ Amorphous
- ❖ Si absorbs only part of the solar spectrum
- ❖ Multi-junction PV cells are emerging

Best research cell efficiencies



http://www.nrel.gov/ncpv

Cost of PV Cells and Systems

Grid Tie Inverter 2000W+ Weekly Retailer Price

Brand	High	Low	Average
All Brands	0.900	0.289	0.465

Unit: US$ / Watt

Grid-Tie Solar System Weekly Retailer Price

Brand	High	Low	Average
All Brands	3.568	1.495	2.761

Unit: US$ / Watt

Solar Panel / Solar Module 120W+ Weekly Retailer Price

Brand	High	Low	Average
All Brands	2.760	0.700	1.092

Unit: US$ / Watt

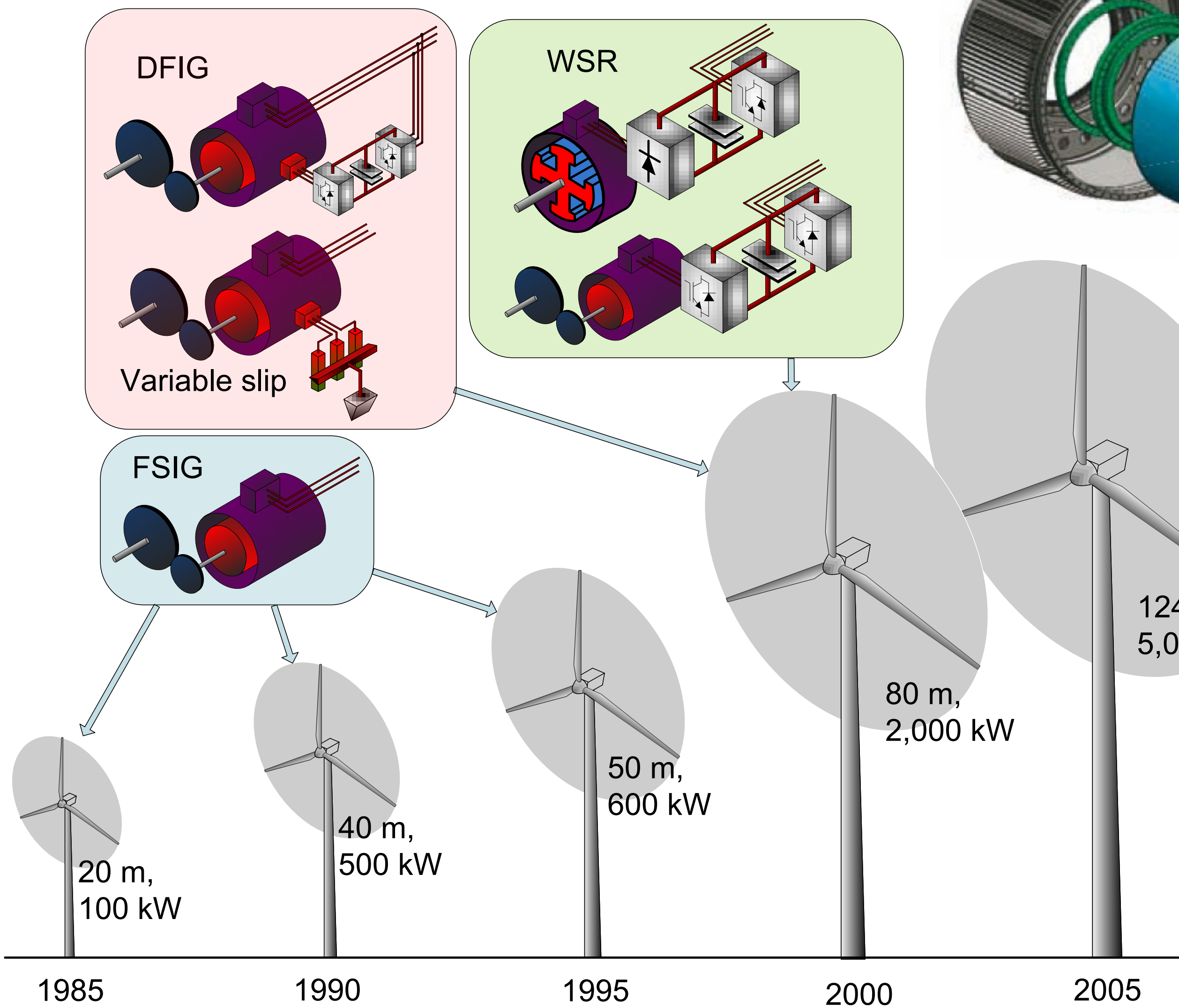
PVinsights
Grid the World

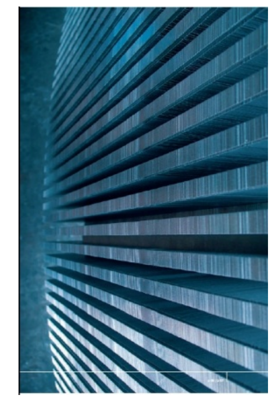
Opportunities we have with PV

- During drought period
  - Reservoir water levels are low
  - Sunshine at least for 10 hrs
- Assume 200 MW of PV installations
  - Power generated within a month

    = 200 x 10 x 30 = 60 GWh
  - Equivalent amount of water can be retain in reservoirs
    - 20% of in Victoria;
    - 40% in Randenigala;
    - 27% in Samanalawewa

Wind Generation



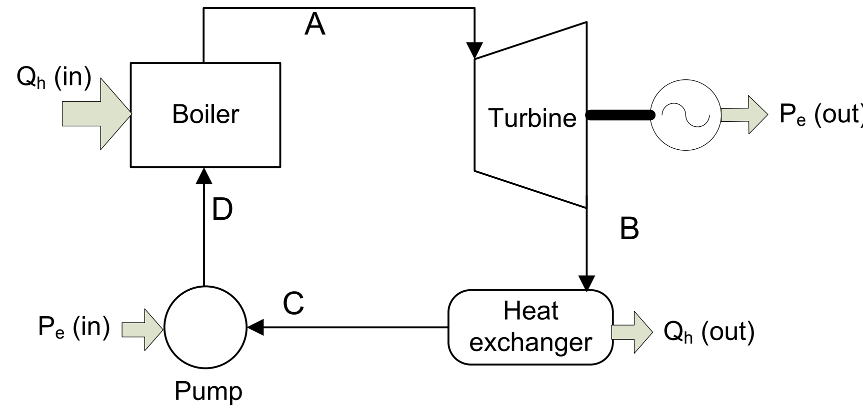


Opportunities we have with wind

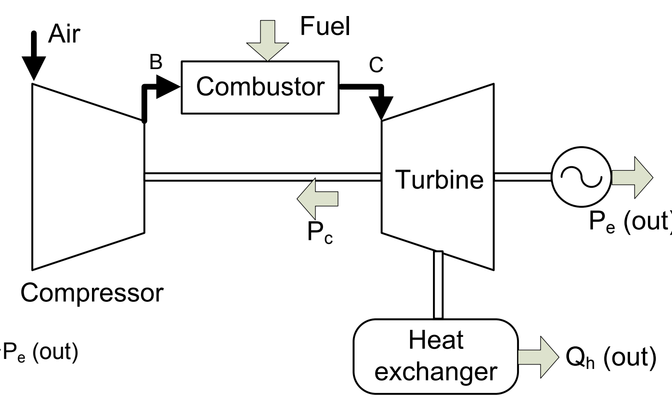
- Wind and rain climate more or less coincide
  - We can use wind and store water for dry season
- Pump storage
  - Pump storage is an ideal storage option to compensate for intermittency
  - Utility is now looking at good sites for pump storage

Other renewables

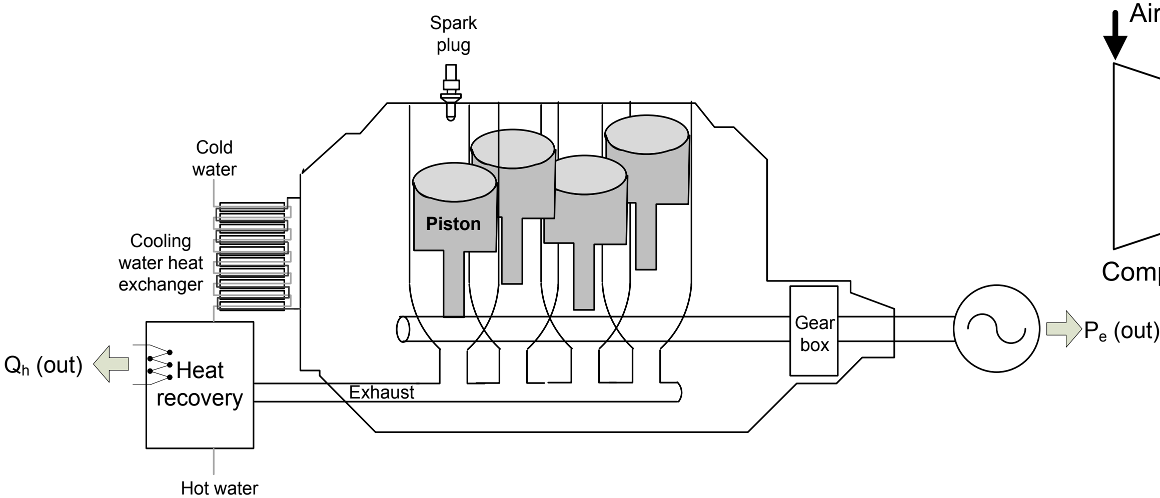
- Co-generation
- Tri-generation
- Biomass/Bio fuel
- Small hydros



Steam turbine



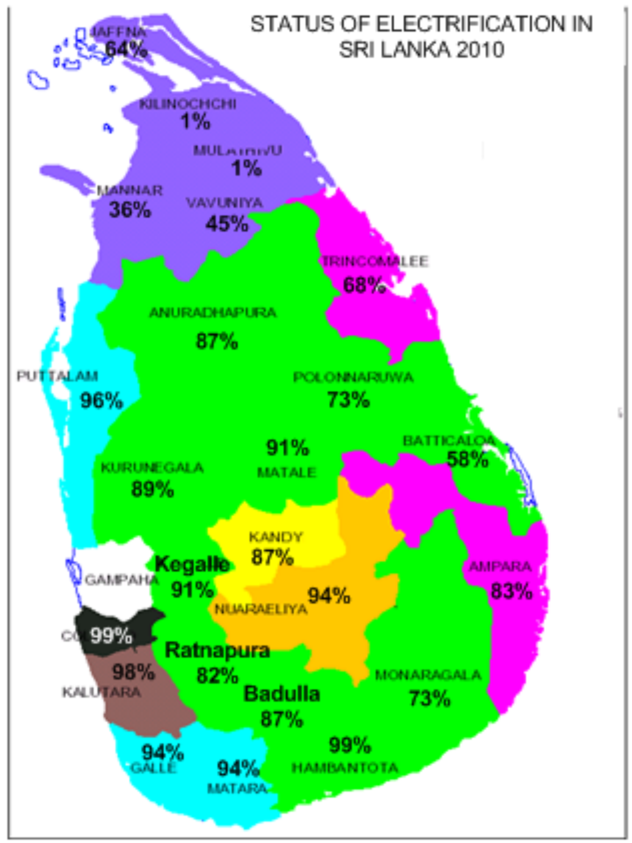
Gas turbine



Reciprocating engines

Opportunities we have with Biomass

- Scrub lands are located in areas where electrification rate and transmission capacity is less



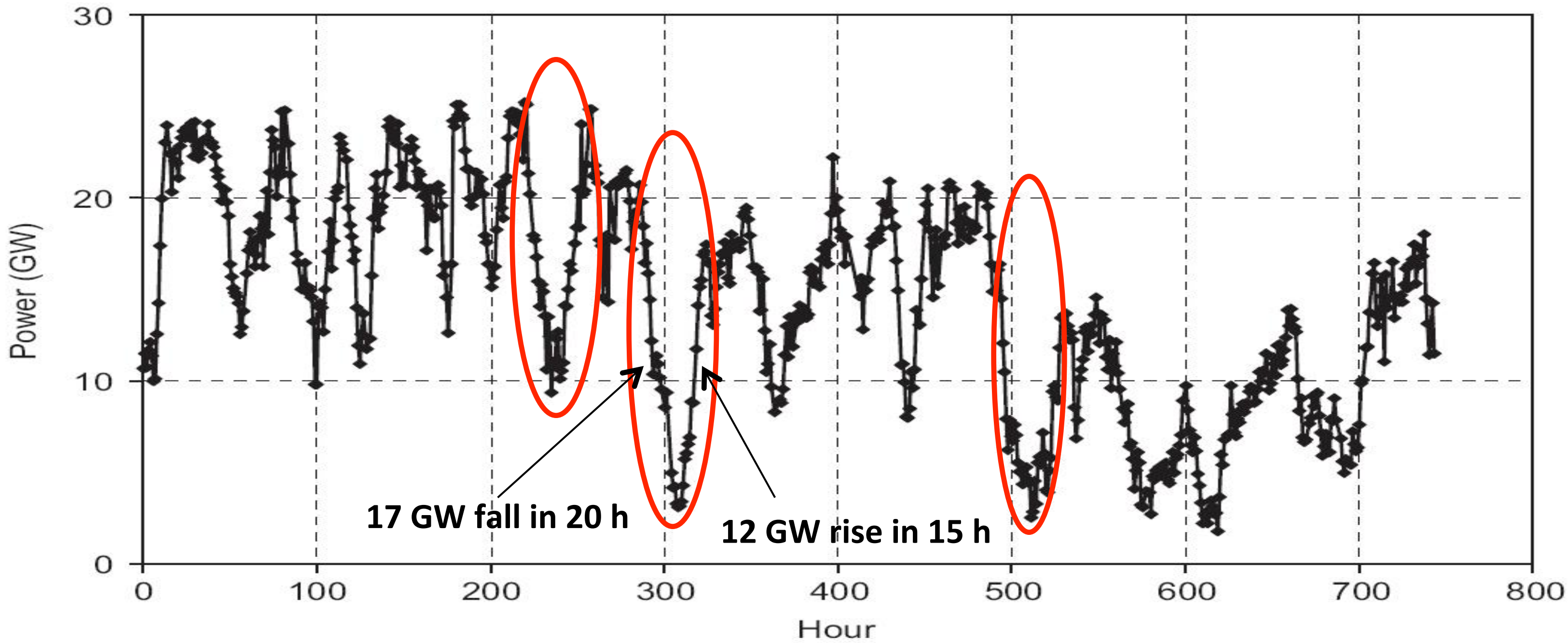
On-going study about NCRE

Scenarios	Total installed capacity of NCRE (MW)									
	2013	2017		2021			2026			
Transition details in intermediate milestones		HH	HS	HW	HB	Aggressive S+H+B	HW	HW	HB	HB
Scenario Code at Planning Horizon							HB	B+W	HW	B+S
Wind	70	190	190	440	290	270	515	640	490	390
Solar	1.5	30	85	40	40	97	60	60	55	300
Biomass	10	60	33	60	225	150	425	375	300	300
Hydro	240	400	279	400	500	400	500	500	500	500
NCRE penetration	9%	15%	12%	20%	21%	17%	25%	25%	20%	20%

B: biomass, H: hydro, S: solar, W: wind,
HH: high hydro, HS: high solar, HW: high wind, HB: high biomass

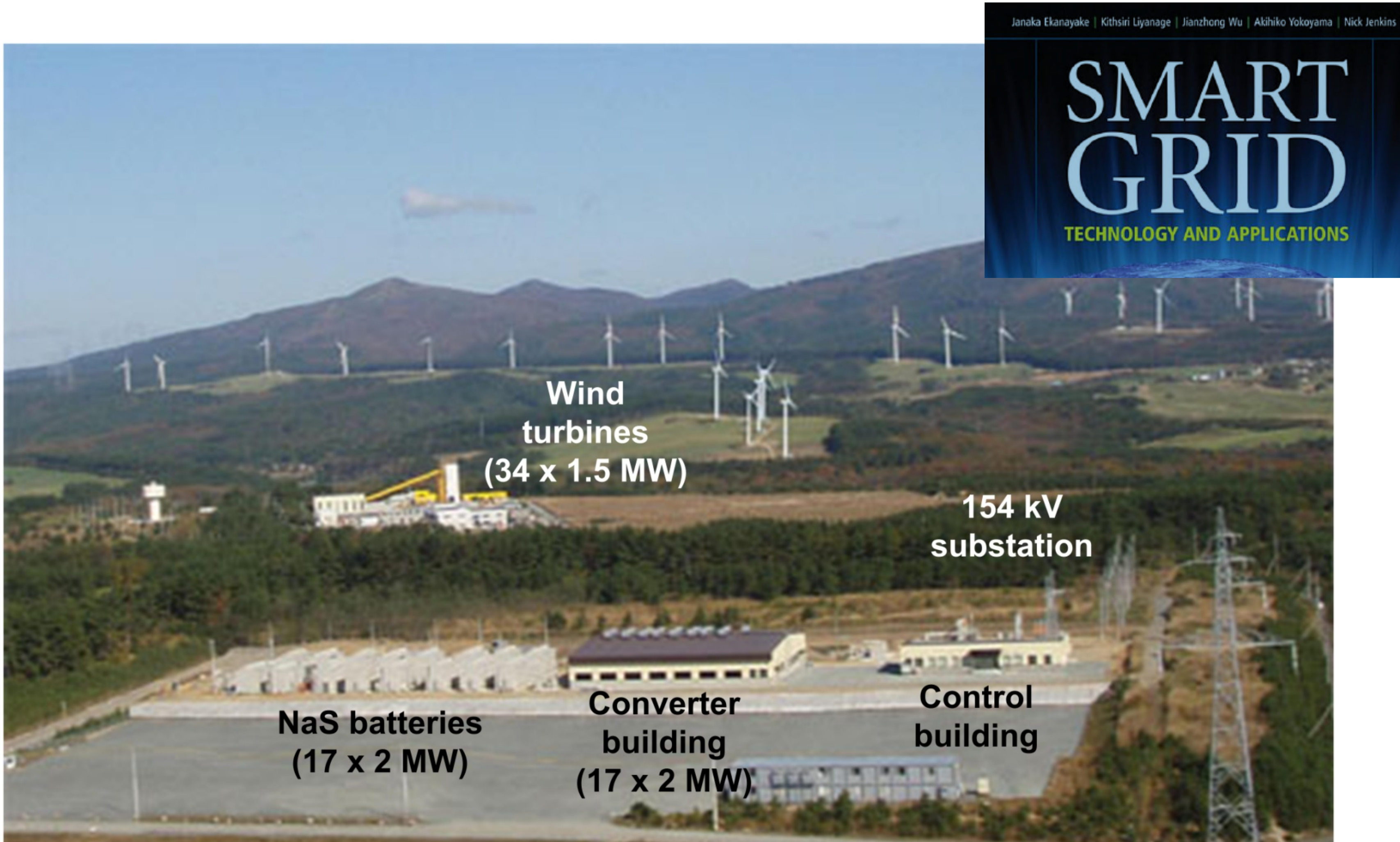
Operational issues

Variability is an issue



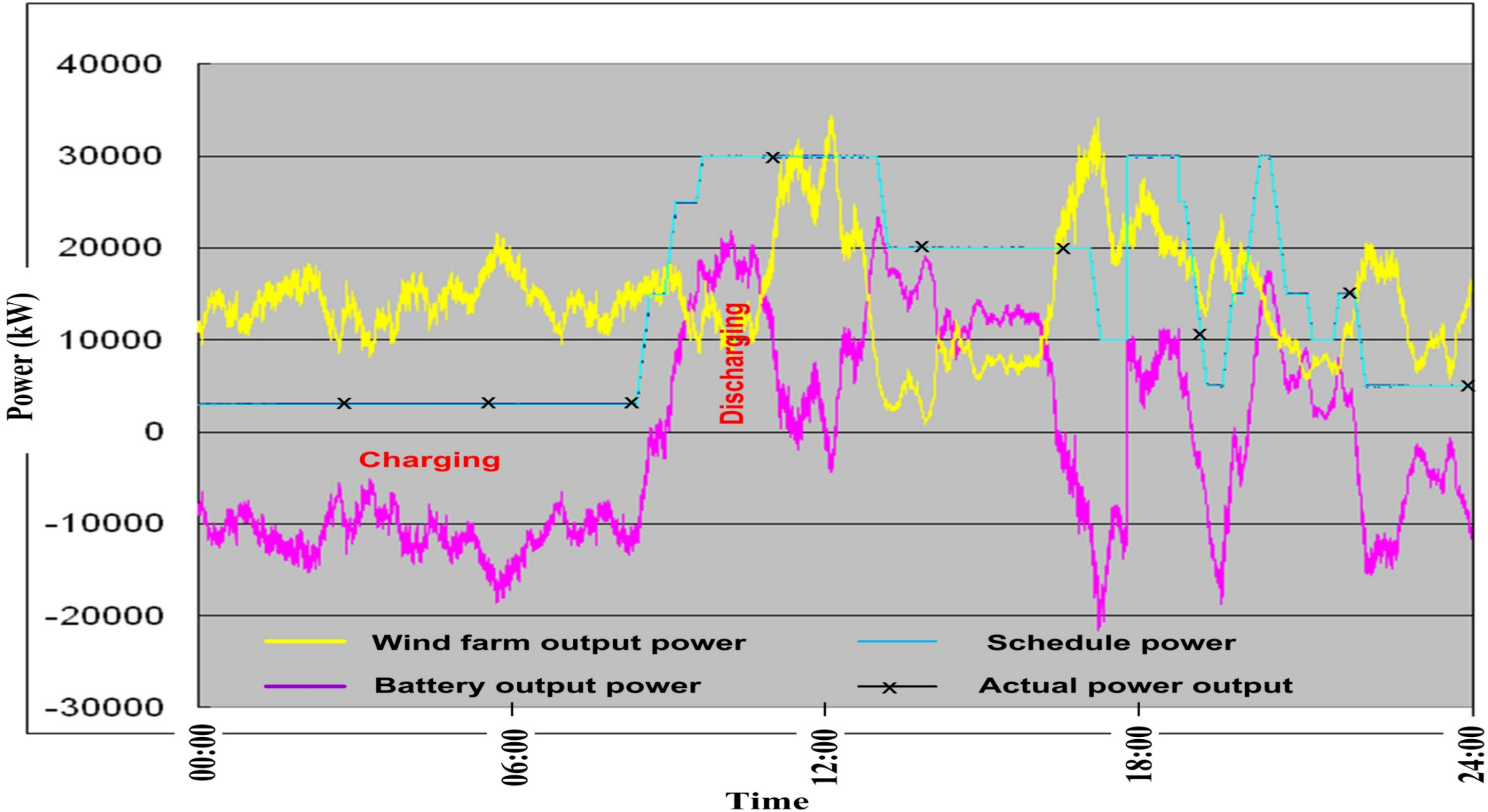
Aggregate wind generation from 25 GW wind farms across GB (Oswald et al., 2008)

Reduced wind variability – Energy storage



Rokkasho wind farm in Japan

Reduced wind variability – Energy storage



Impact on CCGTs

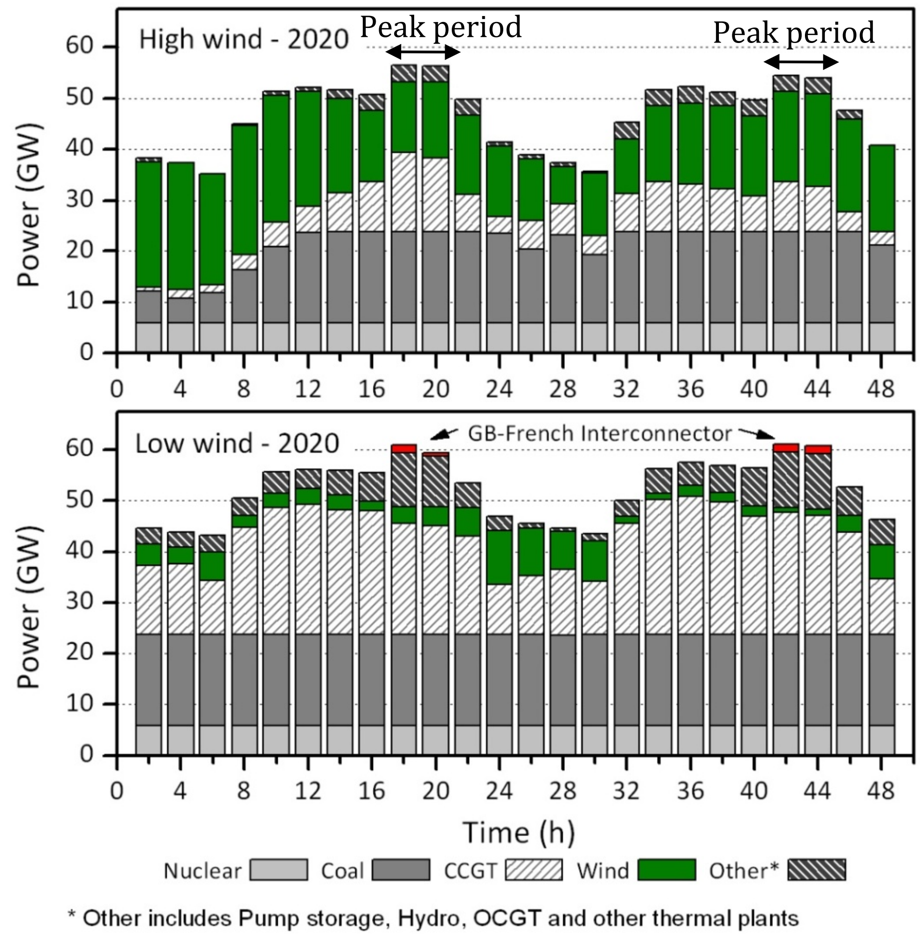
Larger and more frequent CCGT power fluctuations

Low Wind case

- 3.1 GW drop in CCGT output at peak hours due to gas network constraints

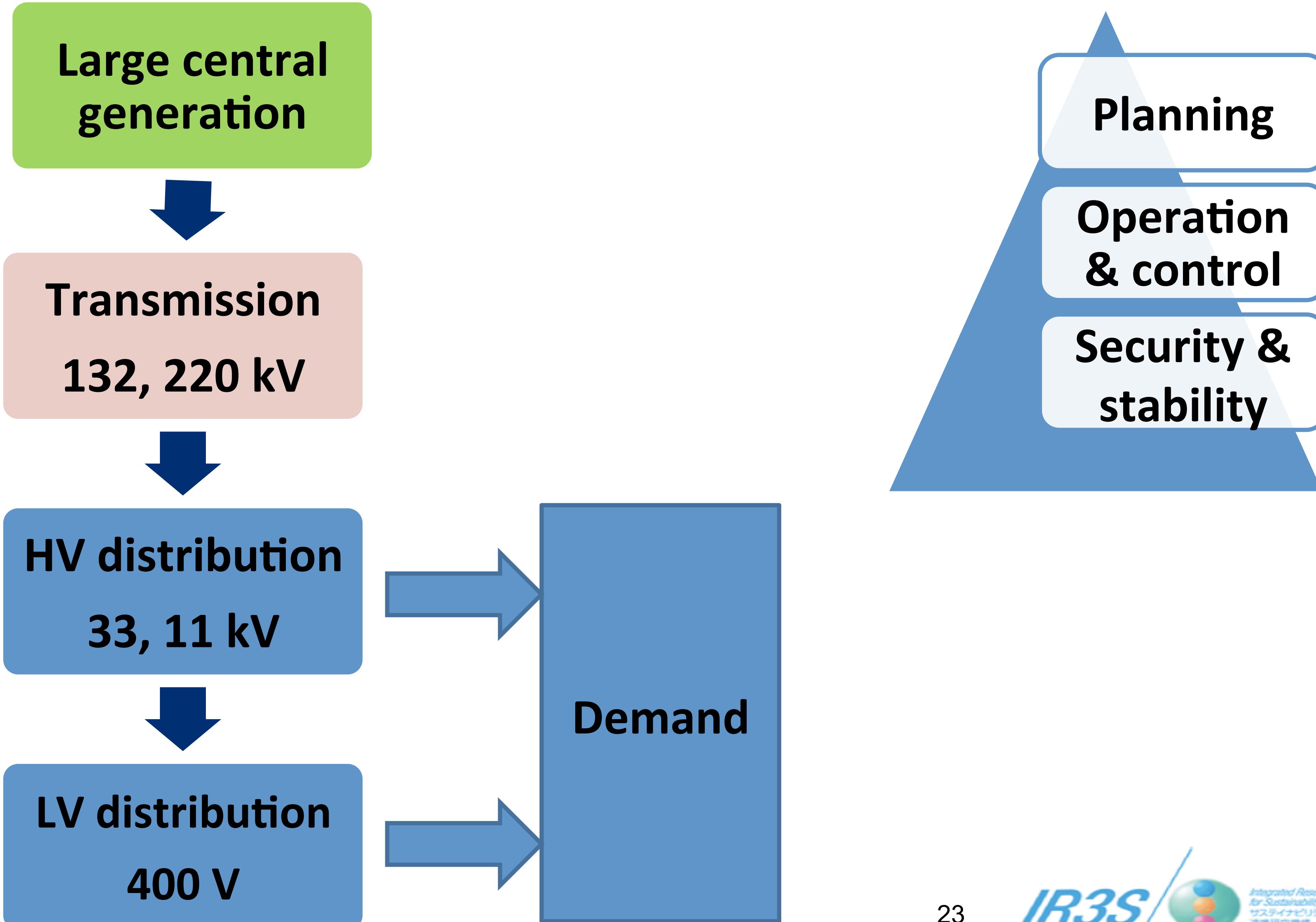
High Wind case

- CCGTs operate at reduced capacity
- More fluctuations: large magnitudes over a short time period
- More CCGT start/stops

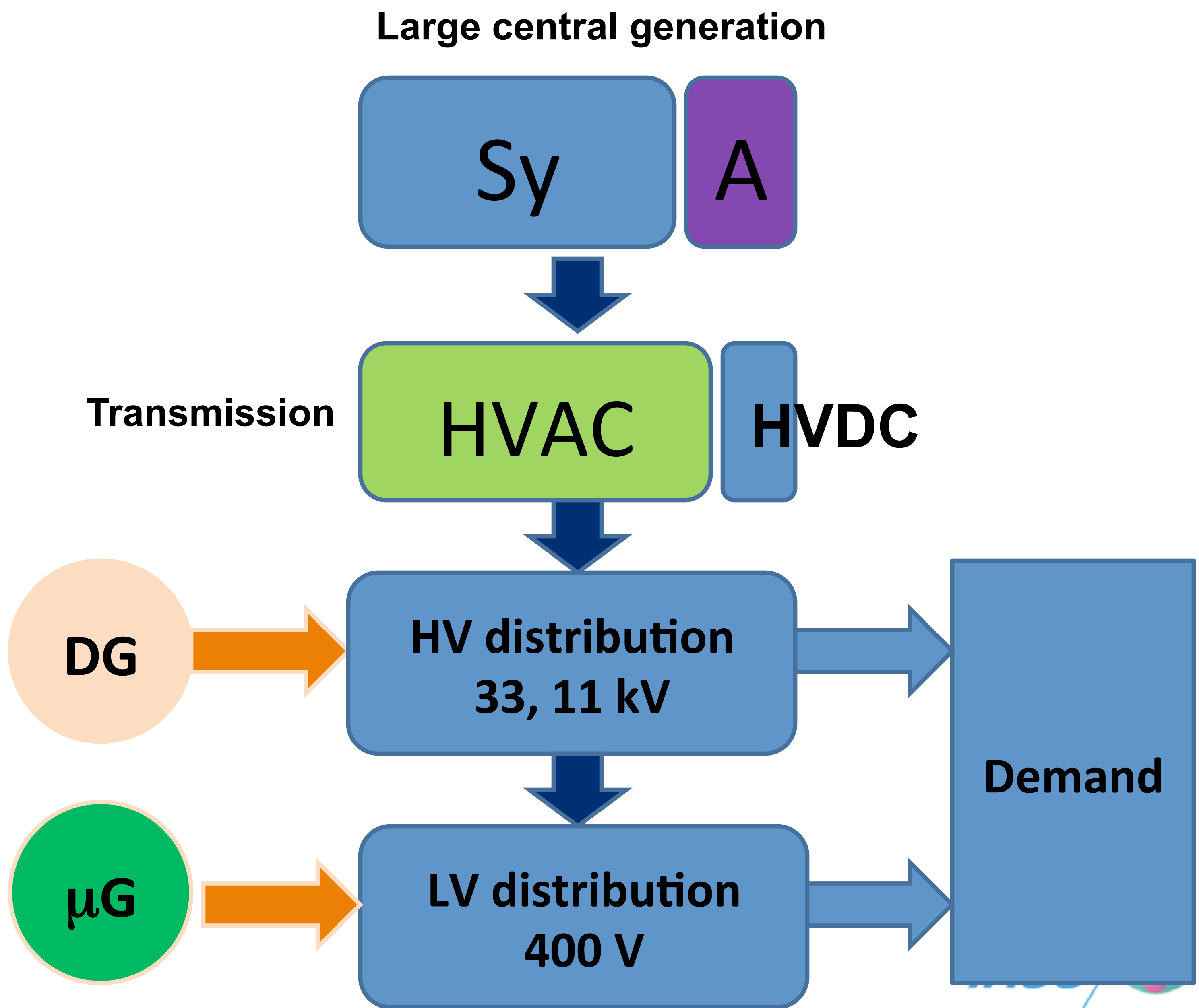


Generation mix for both cases

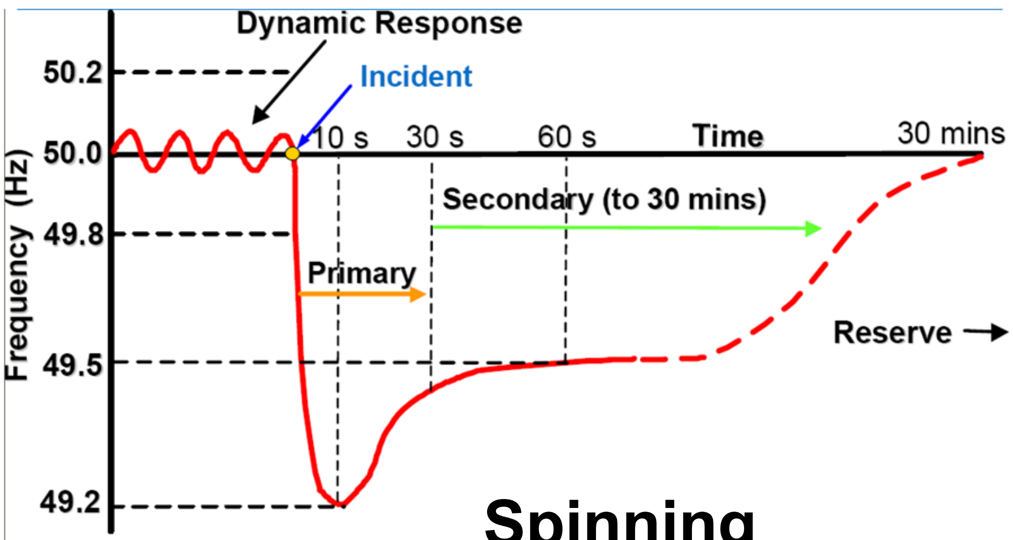
Power System - Past



Power System – Future



Operating future power system

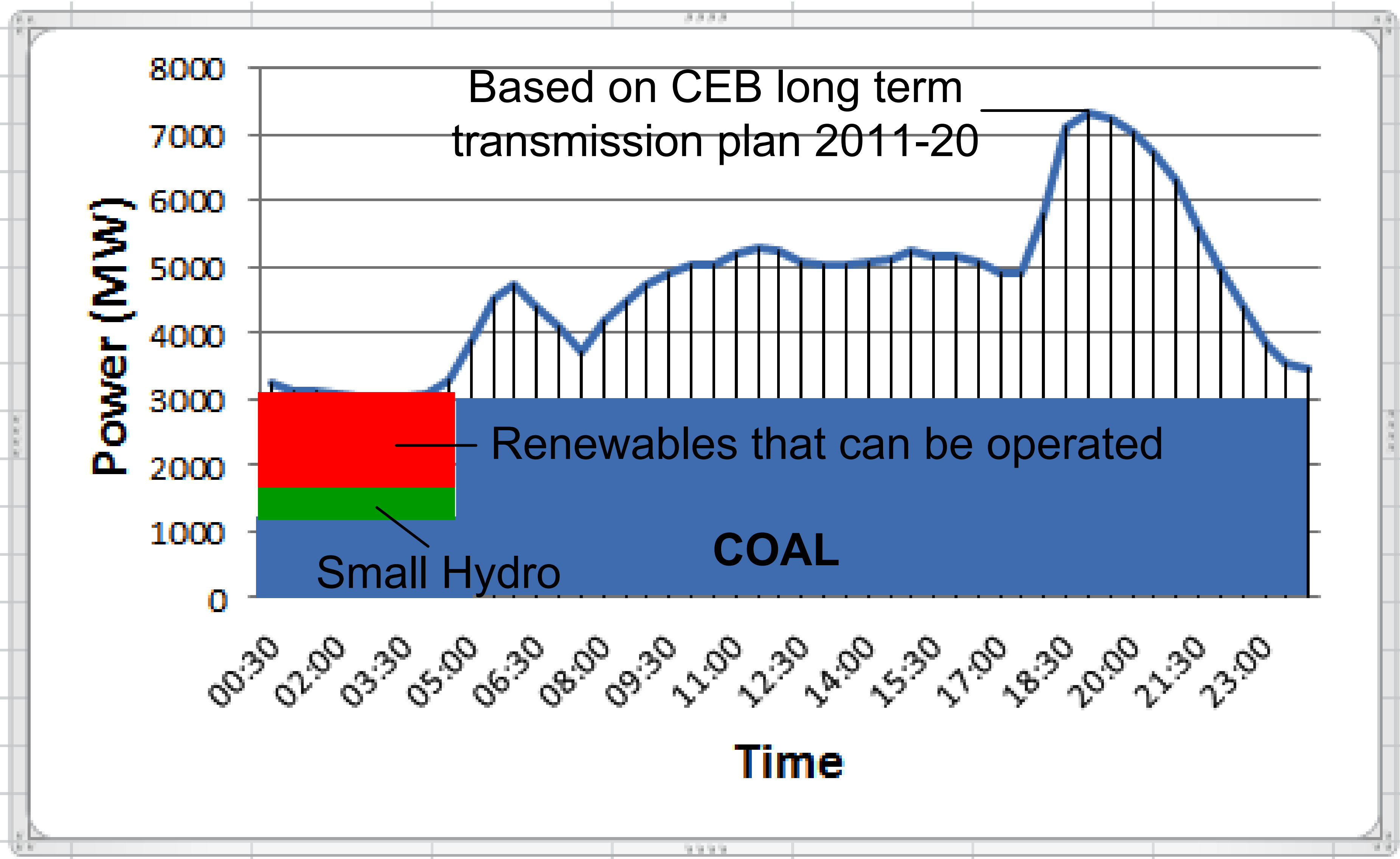


Spinning reserve

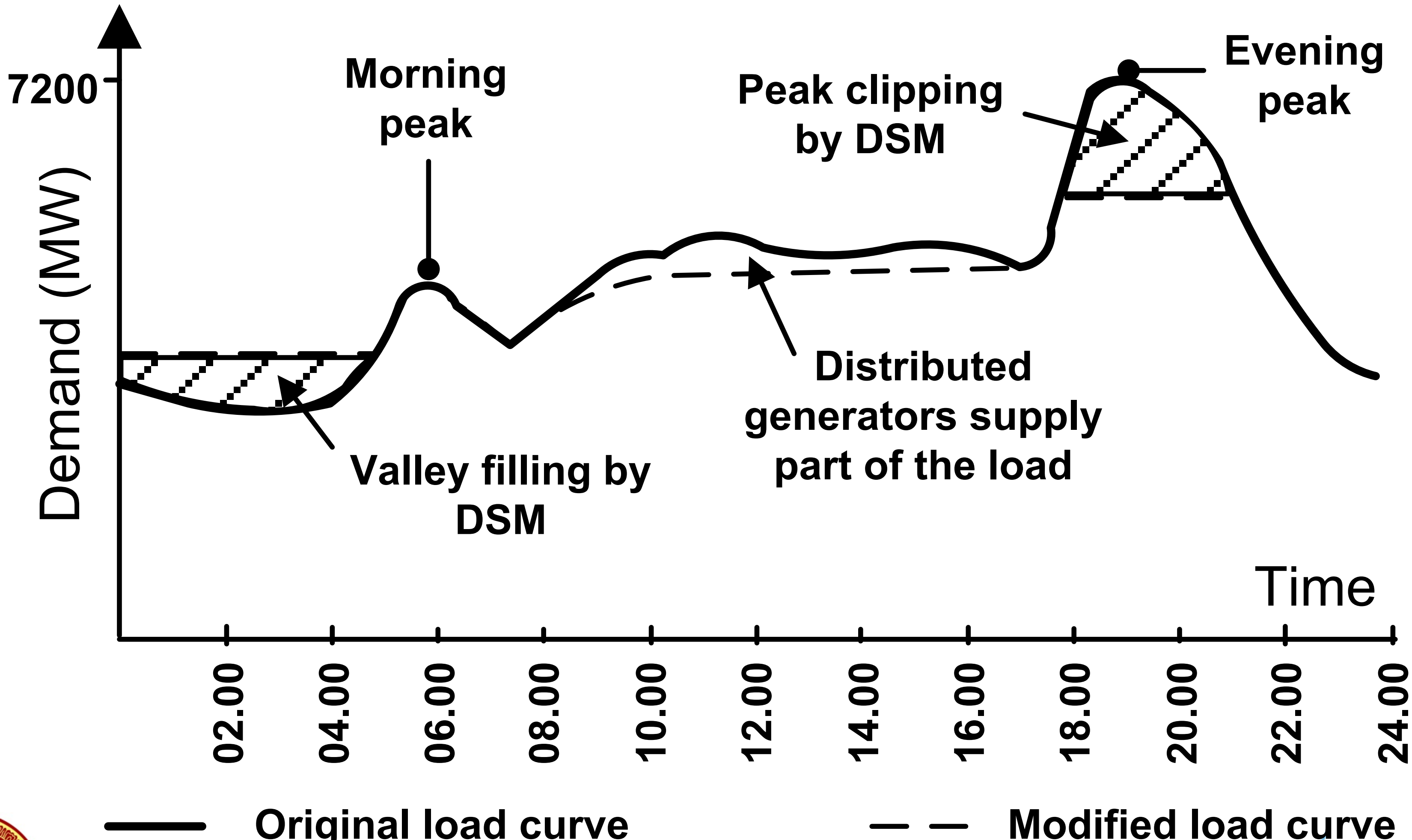
- During a frequency event
  - Less synchronous generators to arrest the frequency collapse

- UK Power system with 25 GW of wind
  - Today: 1.5 GW spinning and 1.5 GW standing
  - This will increase to 9 GW → Flexible demand is a must

Renewable addition with passive loads - 2030

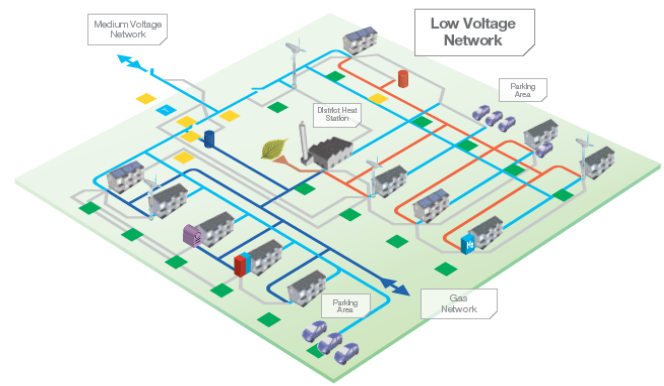


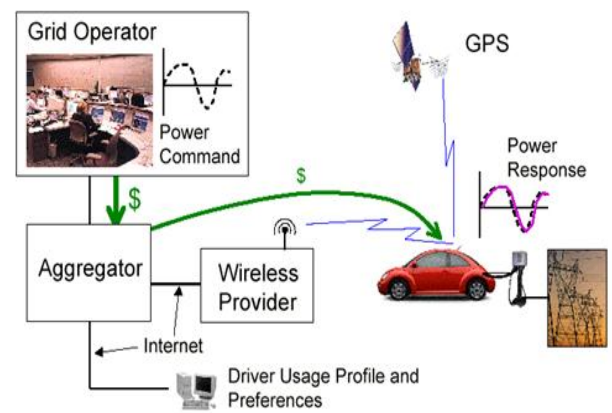
A flexible demand can increase the renewable additions



How could we achieve a flexible demand?

- It is recognised that Smart Grid will play a key role in making the demand flexible
- Smart Metering will be the first step towards getting a flexible demand
- Electric Vehicles add another dimension for flexible demand





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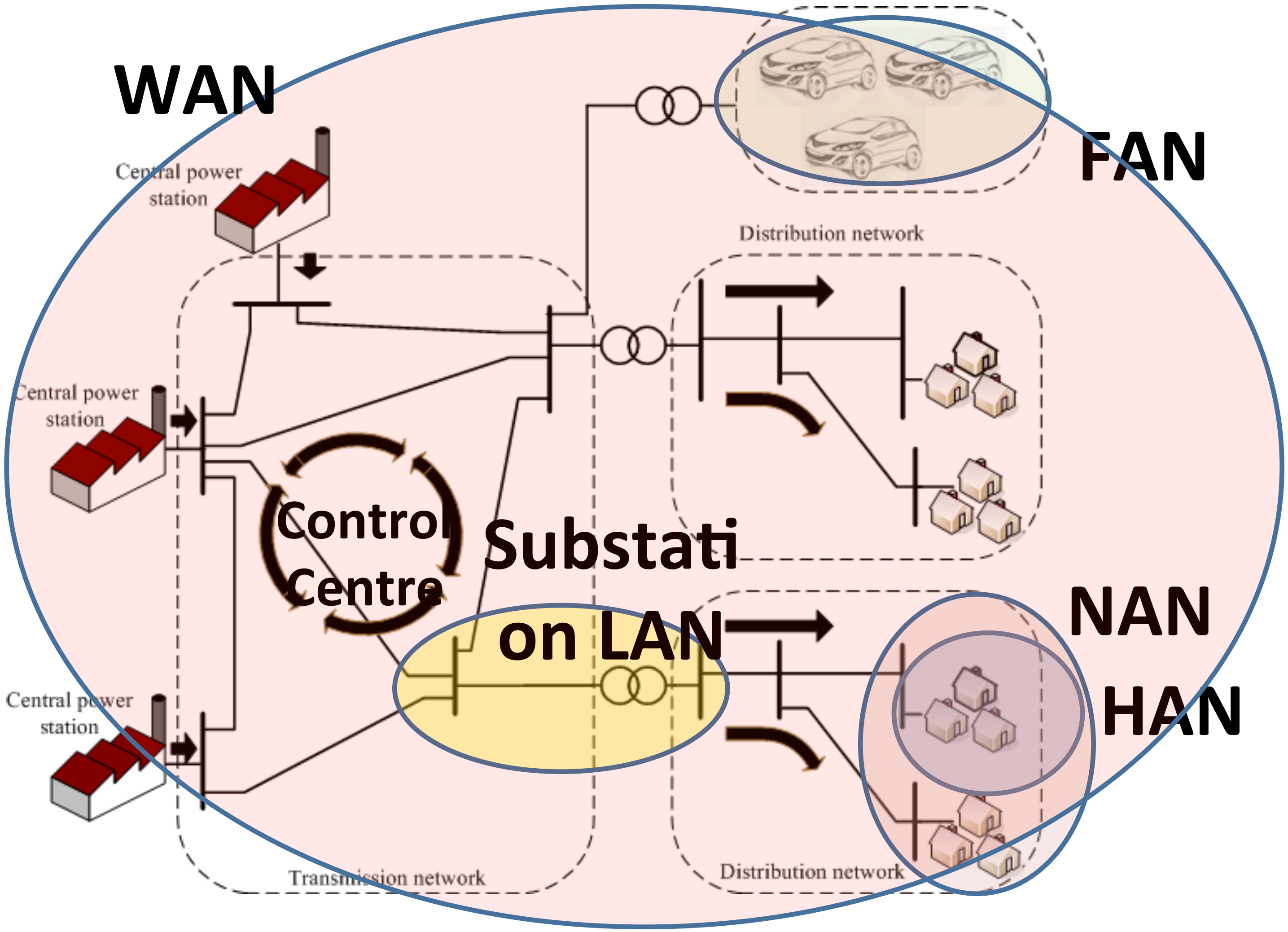
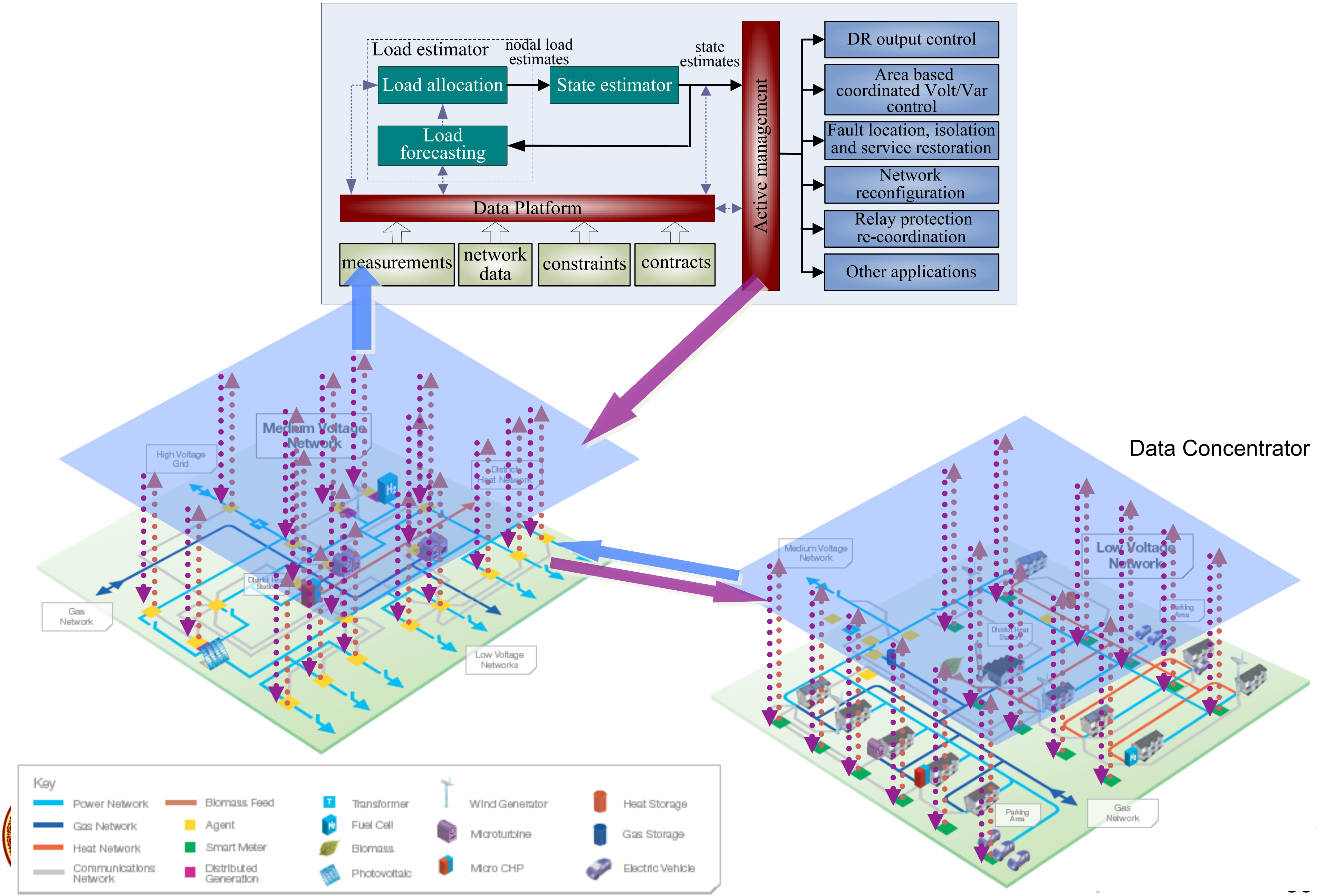
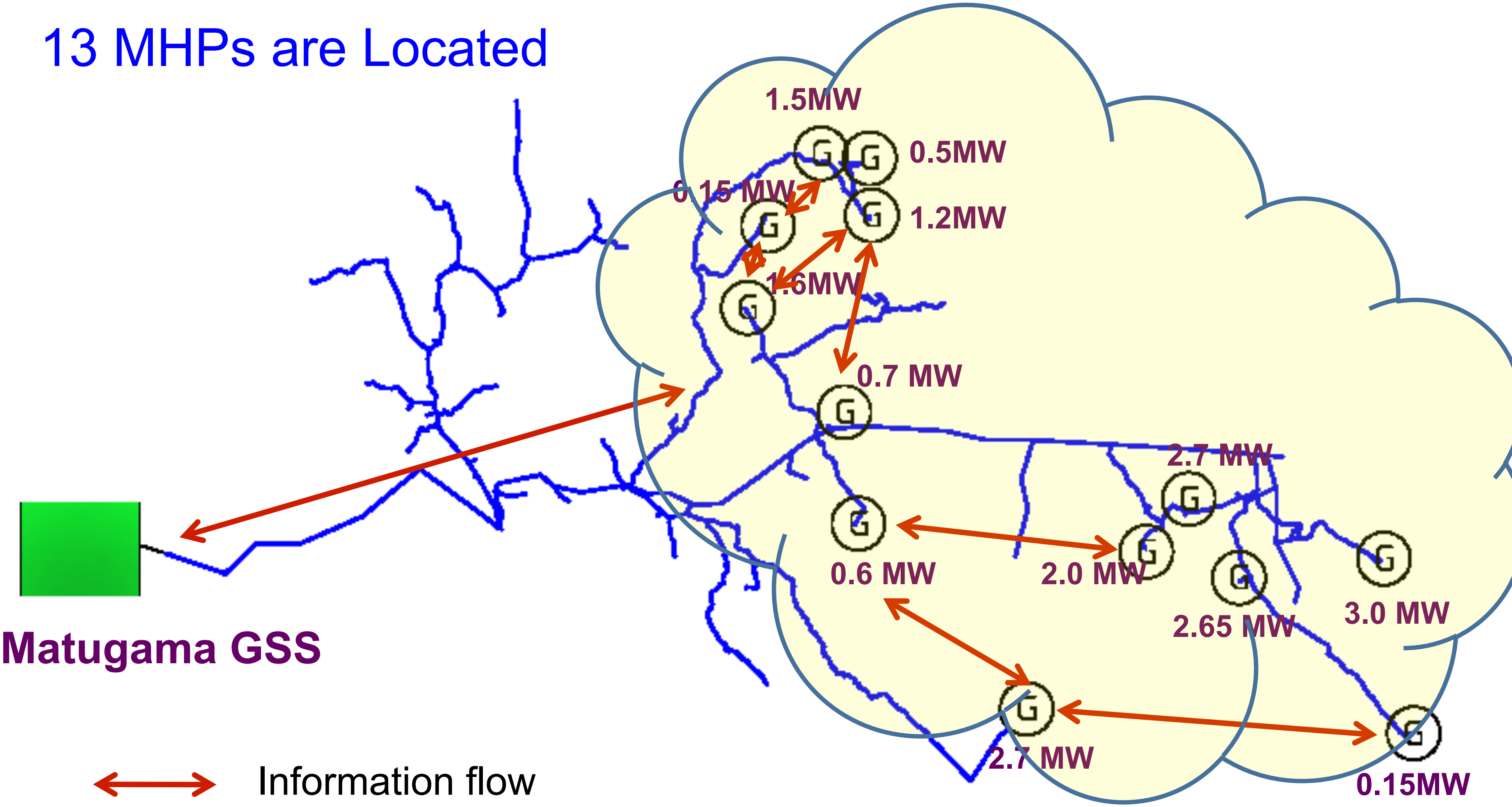


How could we achieve a flexible demand?



Other benefit of ICT infrastructure

13 MHPs are Located



20 MW VPP

Conclusions

- While we are developing Coal power plants, eventually renewables will be added to our power system.
- As Coal can not operate below a certain minimum generation (40% or so), it is important to investigate how the system could be operated safely and reliably with high penetration of renewables;
- Options available to us are:
  - Utilising energy storage
    - It is important to see how variability of renewables could be absorbed by hydros
    - Pump storage

Conclusions

- DSM measures through smart metering; This requires planned smart meter deployment
- Expanding the ICT infrastructure
  - For smart metering
  - For VPP
- If we are to meet our Energy needs while enhancing our commitment to preserve the environment, strategically we must show that the renewables can be added in a **cost-effective** and **grid-friendly** manner; And **Smart Grid** is ideal for this
- I am sure Japanese industry is geared to support Sri Lanka to achieve these objectives