The national and international context for CSP

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Why would customers buy CSP?

Drivers:

- Climate protection: CO_2-free electricity
- Economics: where energy supplied is lower cost than available alternatives
- Energy security: less reliance on imports
- Grid stability: Dispatchable power through thermal storage

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Climate protection: COP21 Paris conference Dec 2015

- 195 countries (essentially the whole world: 193 UN member states, US recognises 195) adopted the first-ever universal, legally binding global climate deal and agreed:
    - a long-term goal of keeping the increase in global average temperature to well below 2°C above pre-industrial levels;
    - to aim to limit the increase to 1.5°C, since this would significantly reduce risks and the impacts of climate change;
    - on the need for global emissions to peak as soon as possible, recognising that this will take longer for developing countries;
    - to undertake rapid reductions thereafter in accordance with the best available science.
- National climate action plans (INDCs) of all countries not yet enough to keep global warming below 2°C
- The agreement traces the way to achieving this target.

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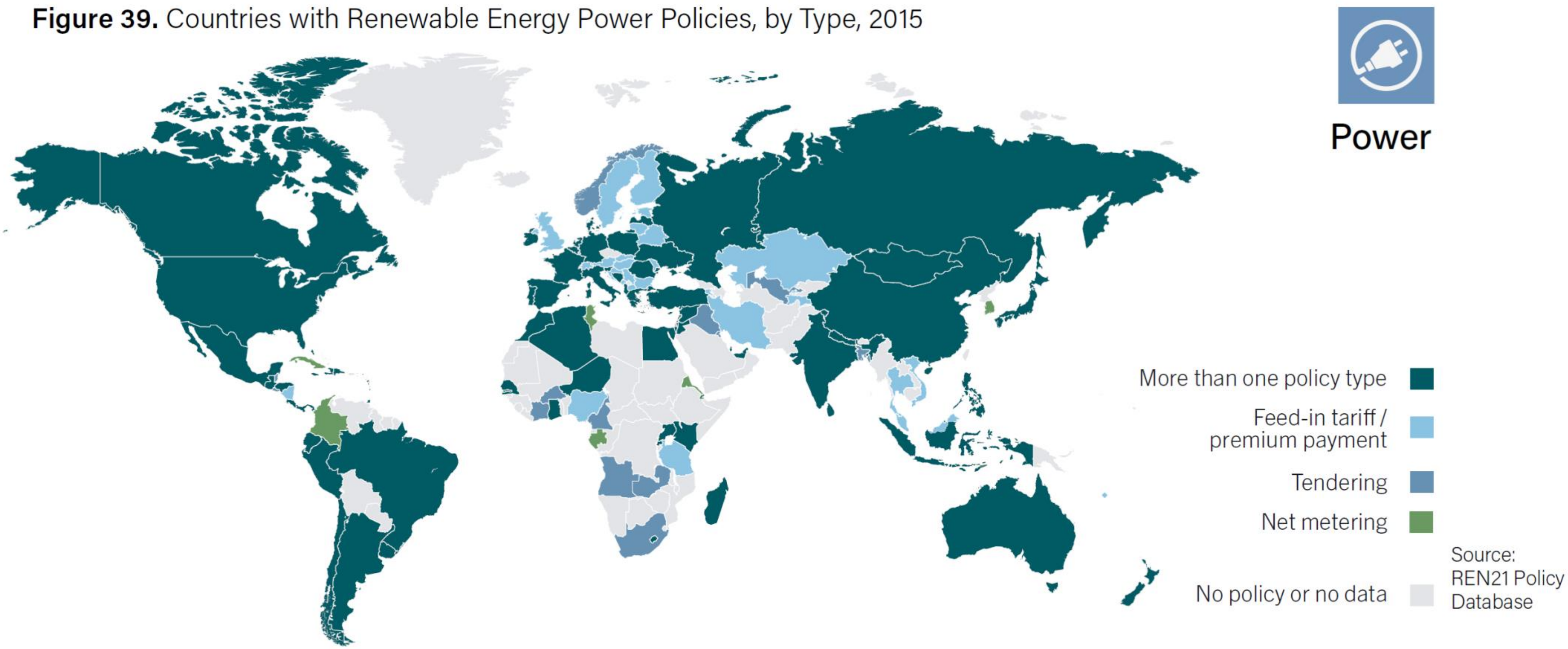
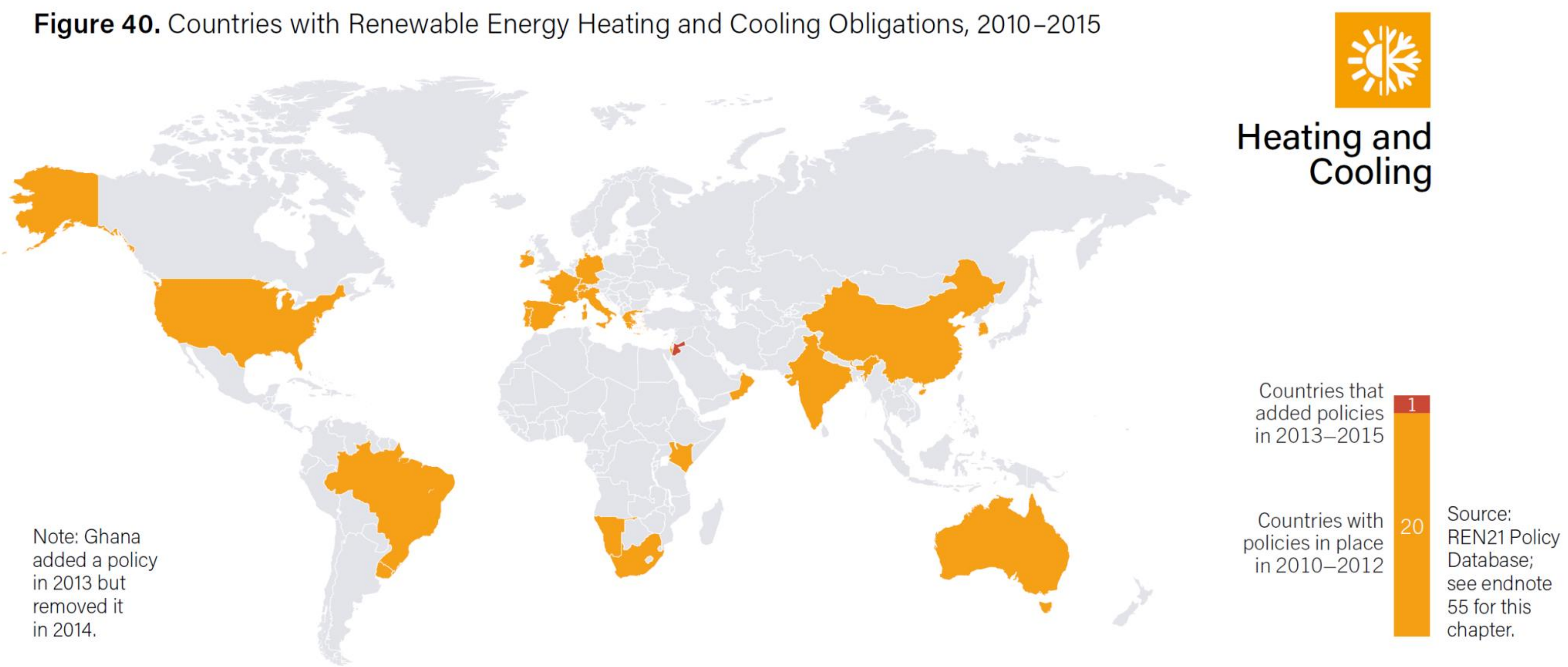
National policies: Renewable Electricity

Figure 39. Countries with Renewable Energy Power Policies, by Type, 2015



Renewables 2016: Global Status Report (REN21)

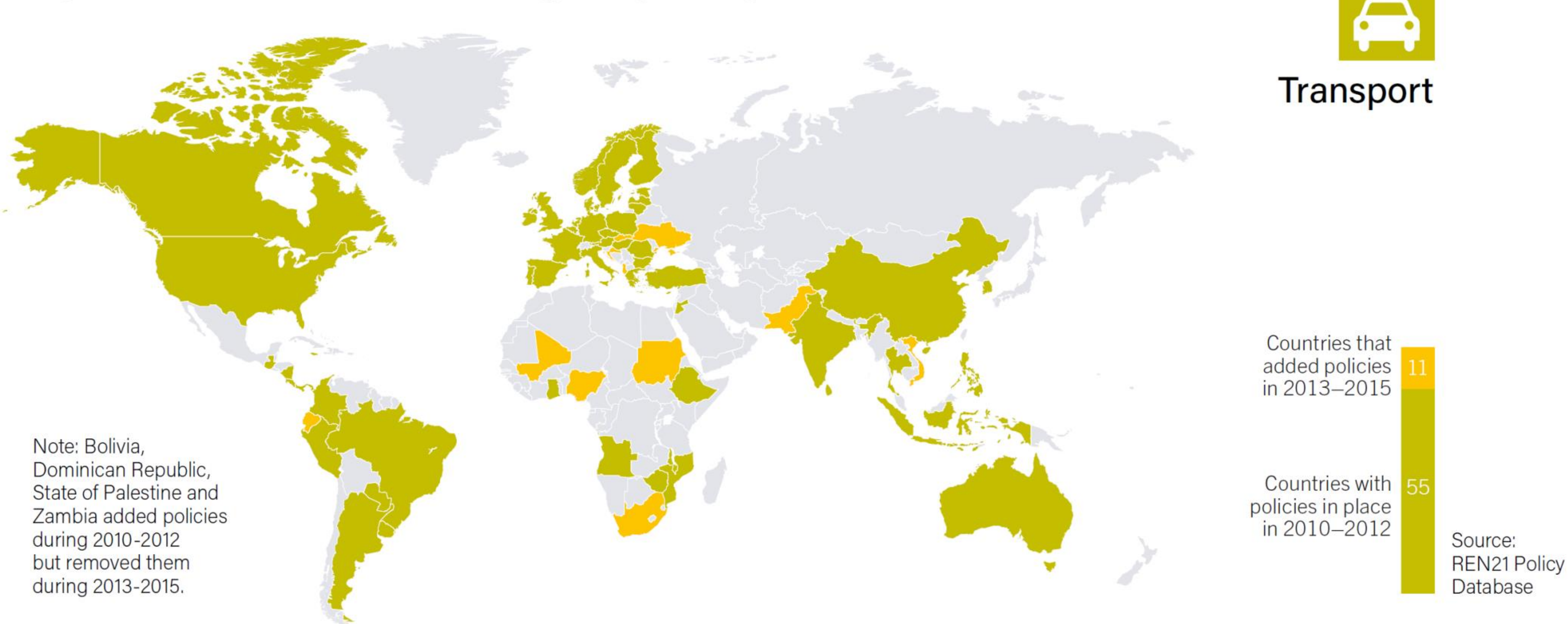
National policies: Renewable Heating and Cooling



Renewables 2016: Global Status Report (REN21)

National policies: Renewable Transport

Figure 41. Countries with Renewable Energy Transport Obligations, 2010–2015



Renewables 2016: Global Status Report (REN21)

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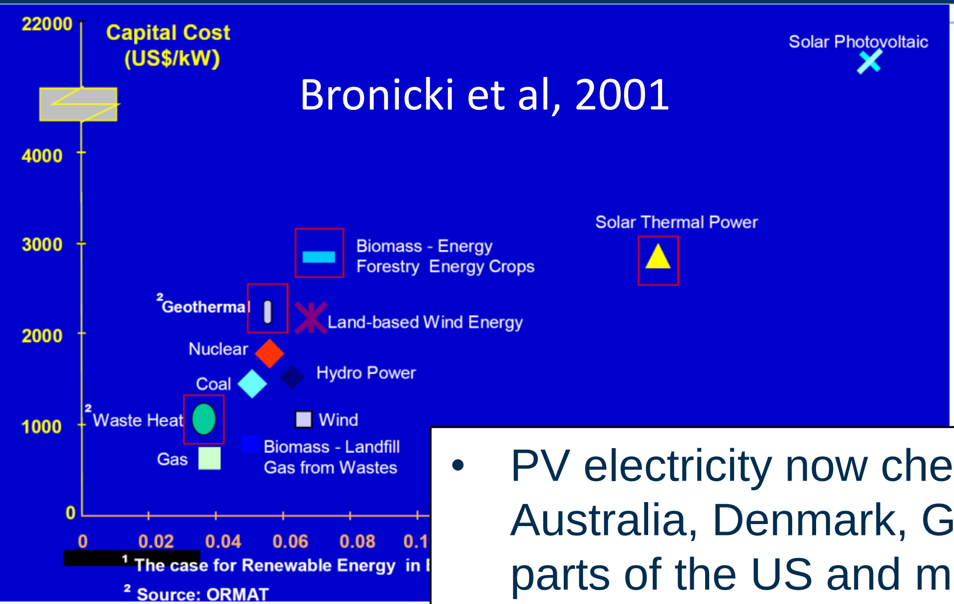
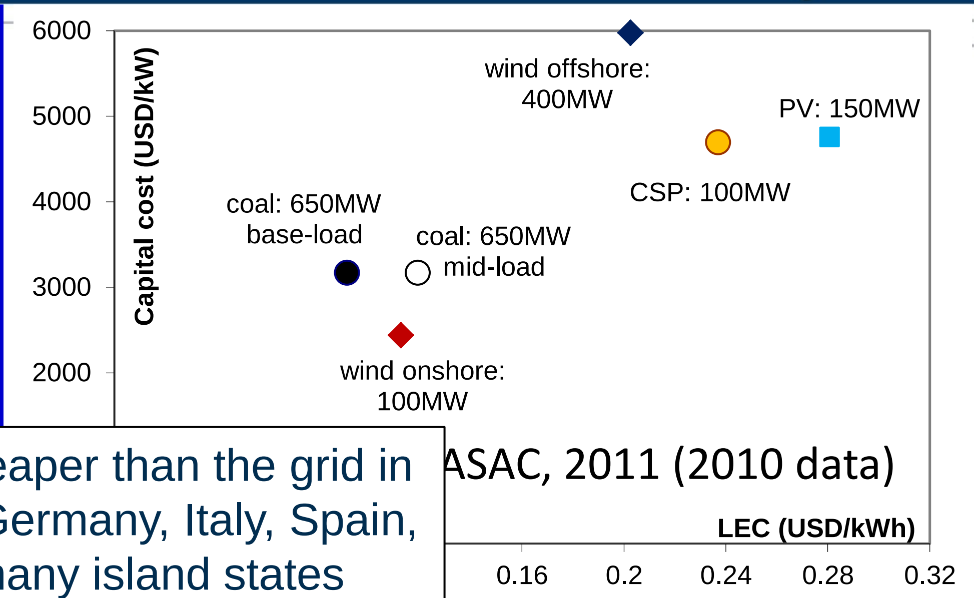
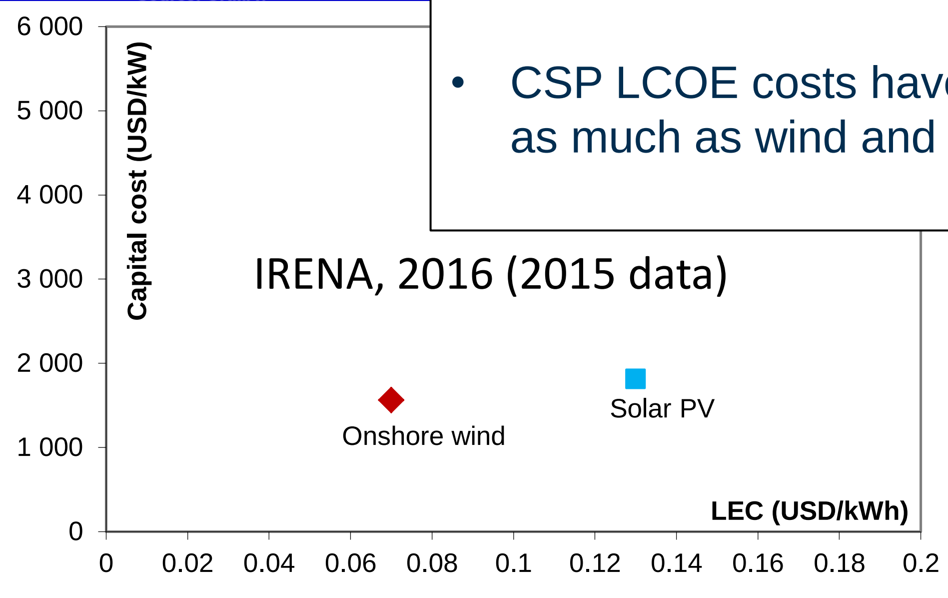
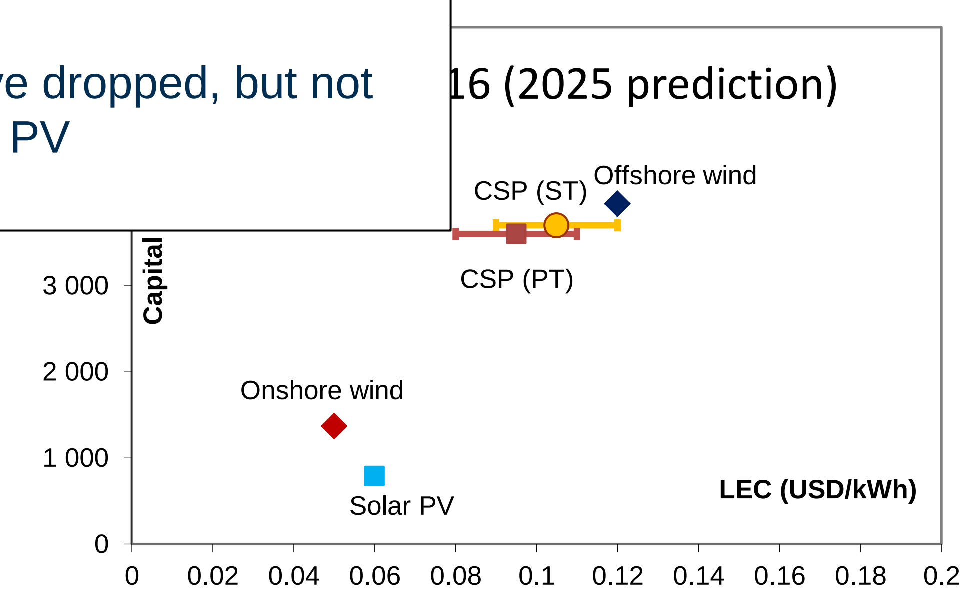
Economics: International timeline







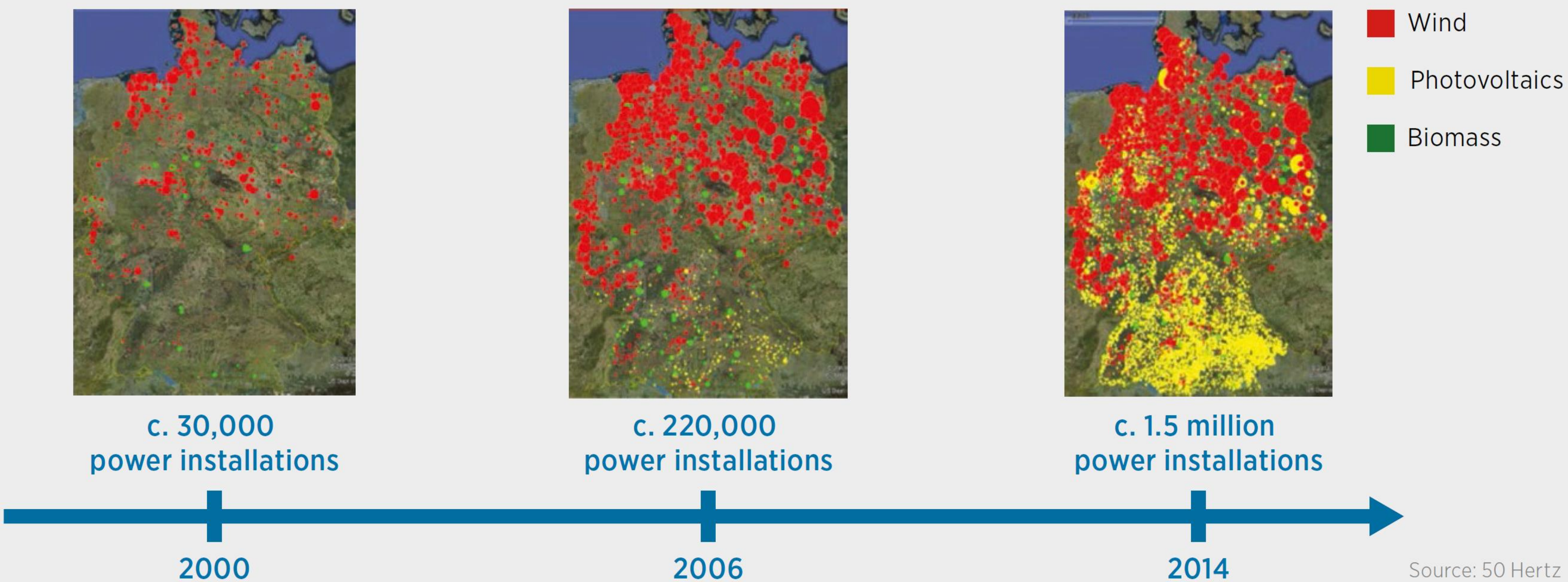


- PV electricity now cheaper than the grid in Australia, Denmark, Germany, Italy, Spain, parts of the US and many island states

- CSP LCOE costs have dropped, but not as much as wind and PV

Economics: Trends (IRENA, 2016)

- ~30% of solar PV installed in 2015 worldwide involved systems < 100 kW
- Many consumers are becoming producers: “prosumers”
- Germany:
  - ~1.5 million rooftop systems installed, the majority owned by individuals
  - Brown and hard coal power stations must follow the residual load, not baseload
  - Business models of power utilities are being placed under pressure



Economics: Trends (IRENA, 2016)

- Shift in the power sector paradigm: Old and new buzzwords

OLD PARADIGM	NEW PARADIGM
Baseload	Variable renewable energy
Centralised grids	Decentralised smart grids
Spinning reserve	Flexibility
Network planning	Big data
Energy-only markets	Energy and capacity markets
Must-run	Curtailment
Rising electricity costs	Falling electricity costs
Energy security	Domestic resources and interconnectors
Air pollution	NIMBY and environmental trade-offs

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Economics: South Africa

- Price per REIPPP round per technology, indexed to April 2013 (DoE: 2013, 2015)

Technology	Round no. and Price (R / kWh)			
	1	2	3	4
Wind	1.284	1.008	0.737	0.583
PV	3.098	1.848	0.99	0.74
CSP	3.017	2.822	1.64 (2.802)	-

- April 2015 comparison, not indexed (Bischof-Niemz, 2016):

Technology	PV	Wind	Baseload Coal	Nuclear	Gas CCGT	Mid-merit Coal	Gas OCGT	Diesel OCGT
Assumed load factor			85%	92%	50%	50%	10%	10%
LCOE R/kWh	0.82 - 0.89	0.65 - 0.75	0.8 - 1.3	1.1 - 1.3	1.0 - 1.3	1.3	1.9 - 2.2	3.1

- Utility-scale PV and wind are now cheapest new-build option, competitive with new coal. Rooftop PV is competitive with municipal tariffs, so economically attractive for companies

- Value of CSP storage recognised in 3rd bidding round, paying 270% of base tariff in peak period (16:30 to 21:30). Still, CSP is most expensive renewable option, and more expensive than all fossil options except Eskom's diesel OCGTs (being converted to gas).

- What is CSP's role in the future energy mix?

CSIR study: Build a new power system from scratch

Base load: **8 GW**

→ Annual demand: **70 TWh/yr (~30% of today's South African demand)**

Questions:

- Technical:
  Can a blend of wind and solar PV, mixed with flexible dispatchable power to fill the gaps supply this?
- Economical: If yes, at what cost?

Assumptions/approach

1. 15 GW wind @ 0.65 R/kWh (Bid Window 4 average tariff)
2. 7 GW solar PV @ 0.82 R/kWh (Bid Window 4 average tariff)
3. 8 GW flexible power generator to fill the gaps @ 2.0 R/kWh (e.g. high-priced gas @ 11.6 $/MMBtu)

- Hourly solar PV and wind data from recent CSIR study, covering the entire country
  - Check out the results: www.csir.co.za/Energy_Centre/wind_solarpv.html
- Hourly simulation of supply structure for an entire year

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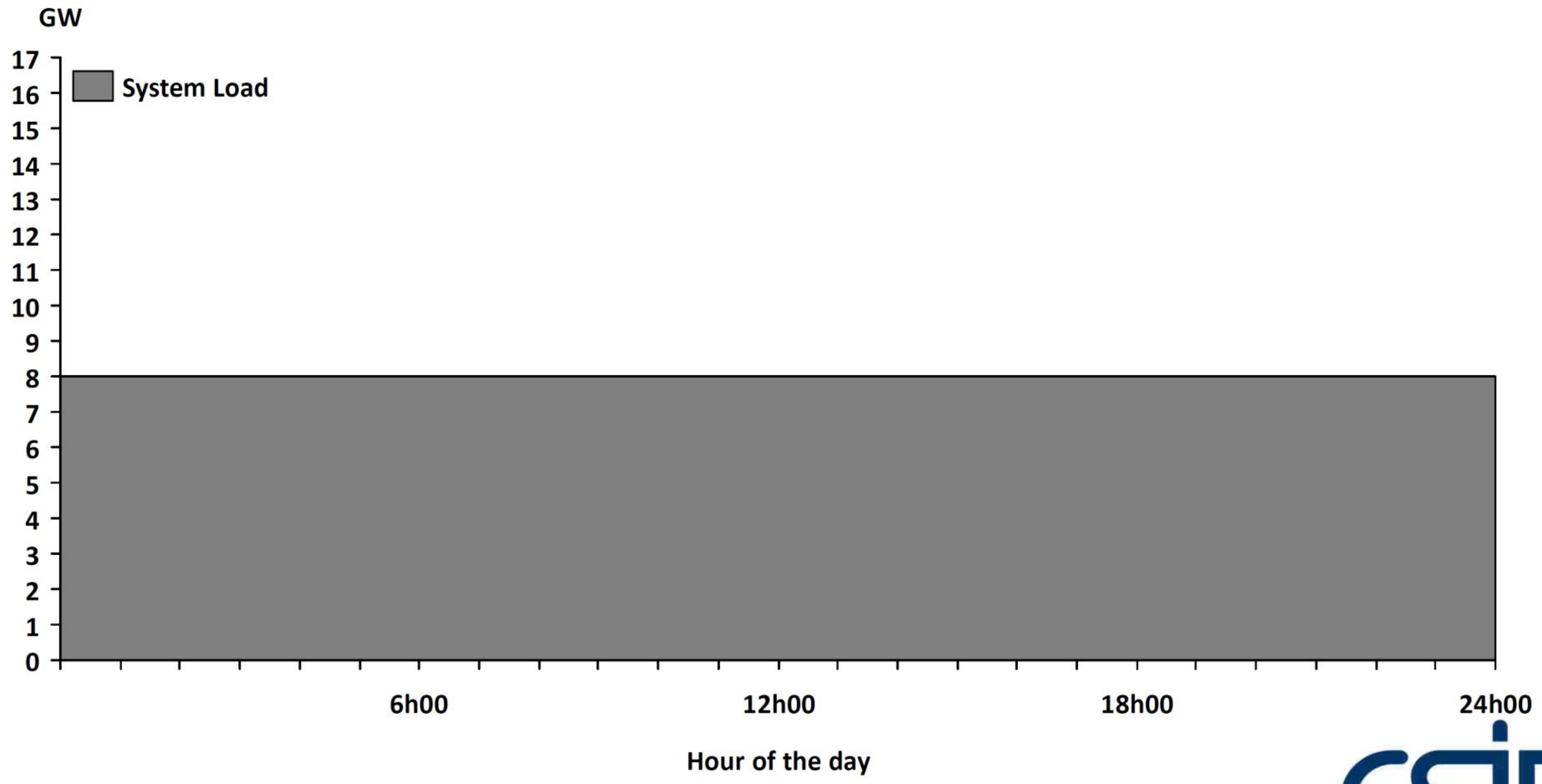
Notes: ZAR/USD = 12.8 (2015 average)
Sources: IRP; REIPPPP outcomes; CSIR analysis

Thought experiment: assumed 8 GW of true baseload



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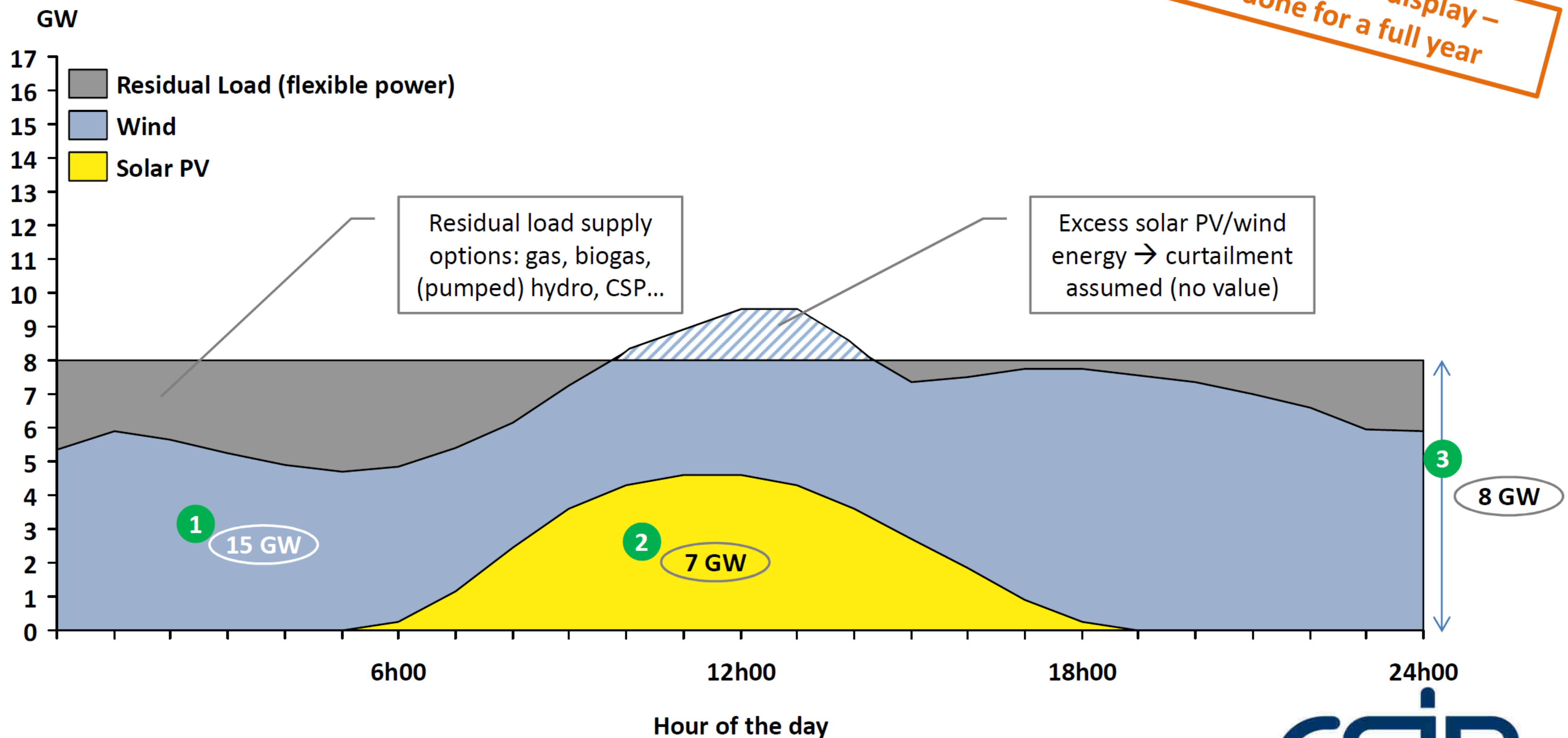
Sources: CSIR analysis

A mix of solar PV, wind and flexible power can supply this baseload demand in the same reliable manner as a base-power generator

One illustrative day in display – simulation done for a full year



Total installed capacity: 30 GW to supply 8 GW baseload – does this make sense? Yes, it's about energy, not capacity!

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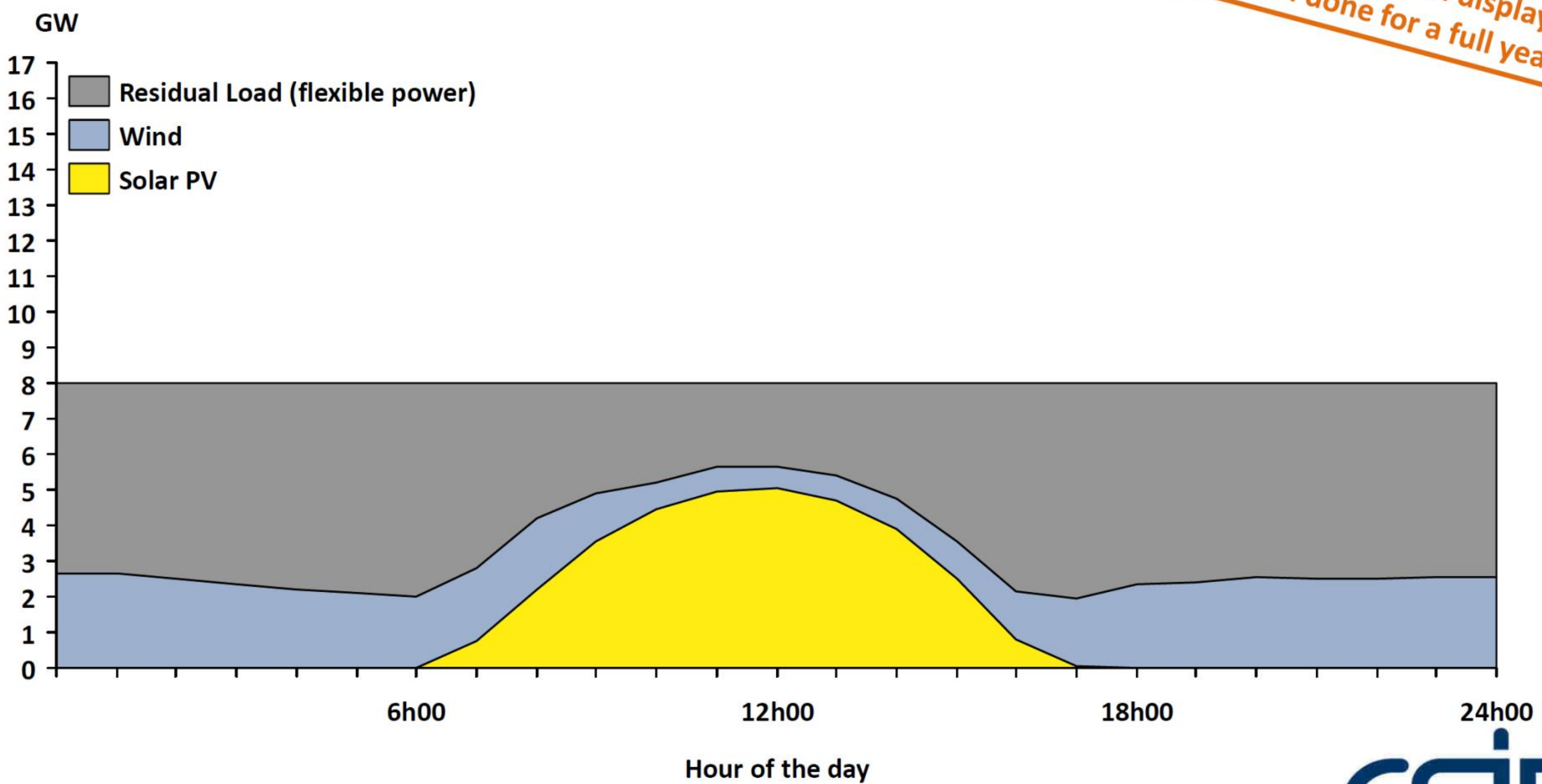
Sources: CSIR analysis

On a low-wind day the residual load is large

Simulated solar PV and wind power output for a 7 GW PV and 15 GW wind fleet on a day in May

One illustrative day in display – simulation done for a full year



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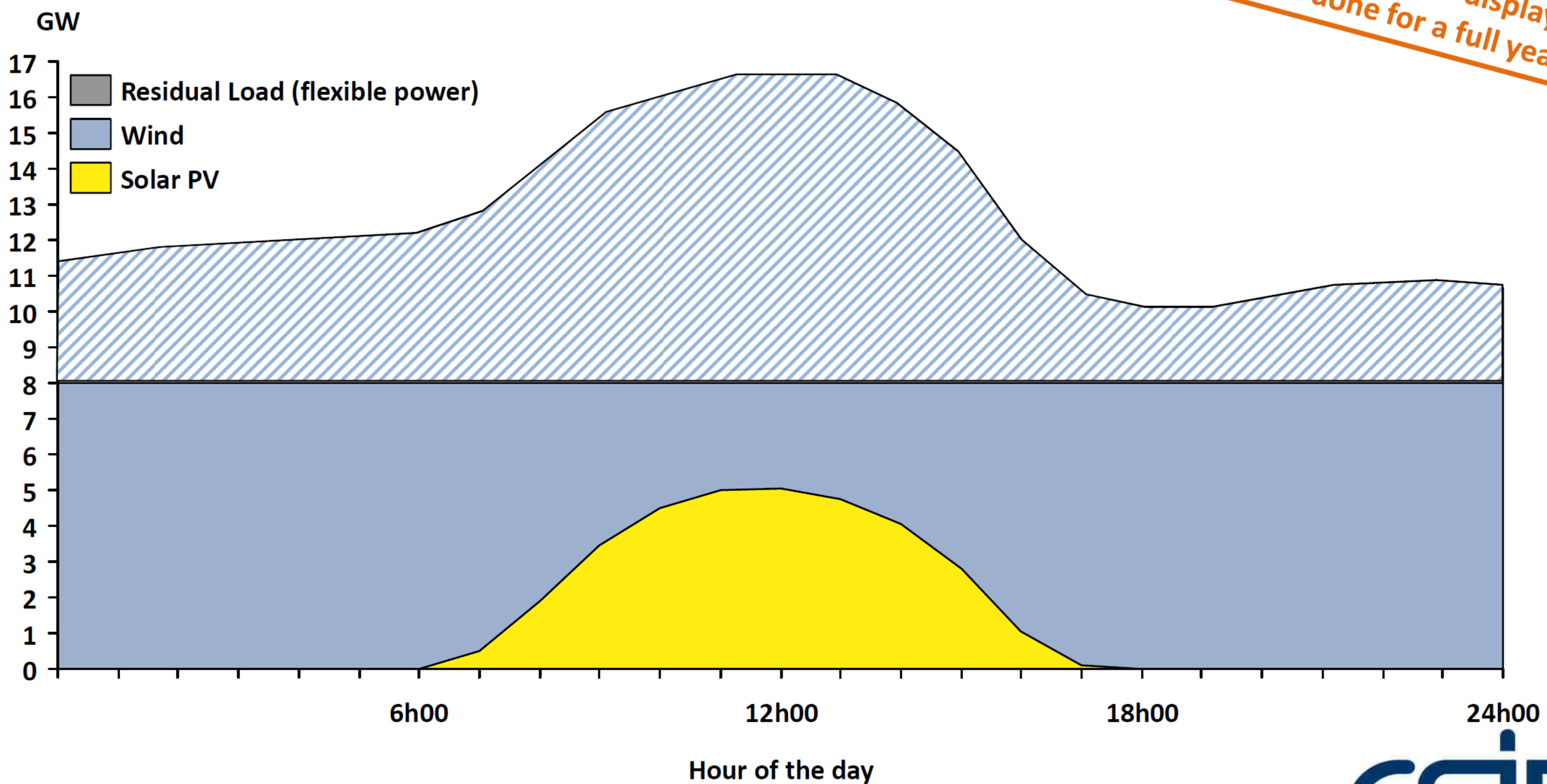
Sources: CSIR analysis

On a sunny and windy day, excess energy from PV and wind is large

Simulated solar PV and wind power output for a 7 GW PV and 15 GW wind fleet on a day in July

One illustrative day in display – simulation done for a full year



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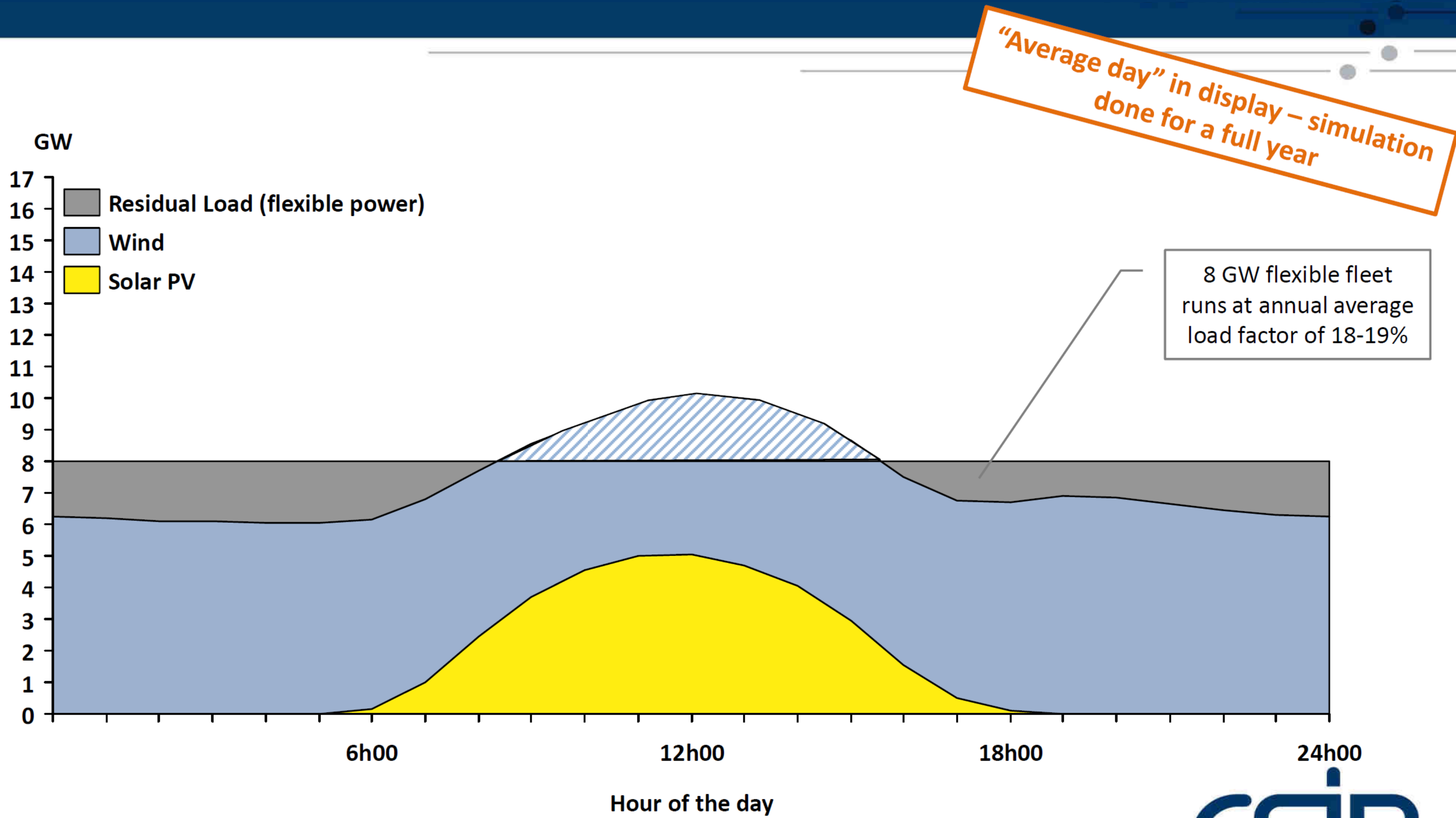
Sources: CSIR analysis

On average, solar PV and wind supplies 82% of the total demand

Average hourly solar PV and wind power supply calculated from simulation for the entire year



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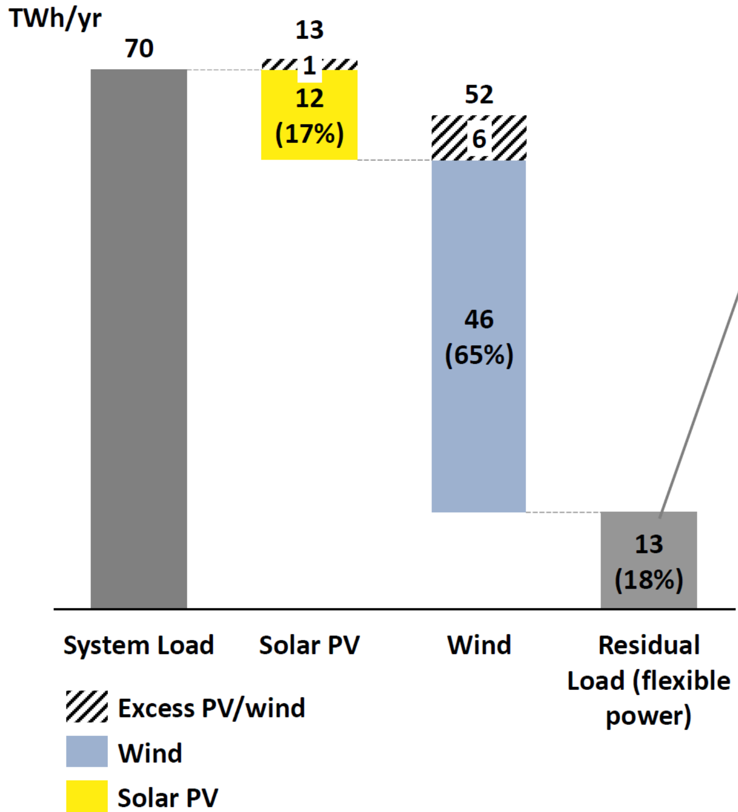
Sources: CSIR analysis

Mix of solar PV, wind and expensive flexible power costs 1 R/kWh (excess thrown away) – same level as alternative baseload new-builds



Sources: CSIR analysis

Requires approx. 30 TWh/yr of natural gas → 2 mmtpa of LNG-based natural gas

New-build baseload coal: 0.82-1.10 R/kWh

$$\frac{13\ \text{TWh/yr} \cdot 0.82\ \text{R/kWh} + 52\ \text{TWh/yr} \cdot 0.65\ \text{R/kWh} + 13\ \text{TWh/yr} \cdot 2.00\ \text{R/kWh}}{70\ \text{TWh/yr}} = 1.01\ \text{R/kWh}$$

- No value given to 7 TWh/yr of excess energy (bought and "thrown away")
- Bid Window 4 costs for PV/wind (no further cost reduction assumed)
- Very high cost for flexible power of 2.00 R/kWh assumed

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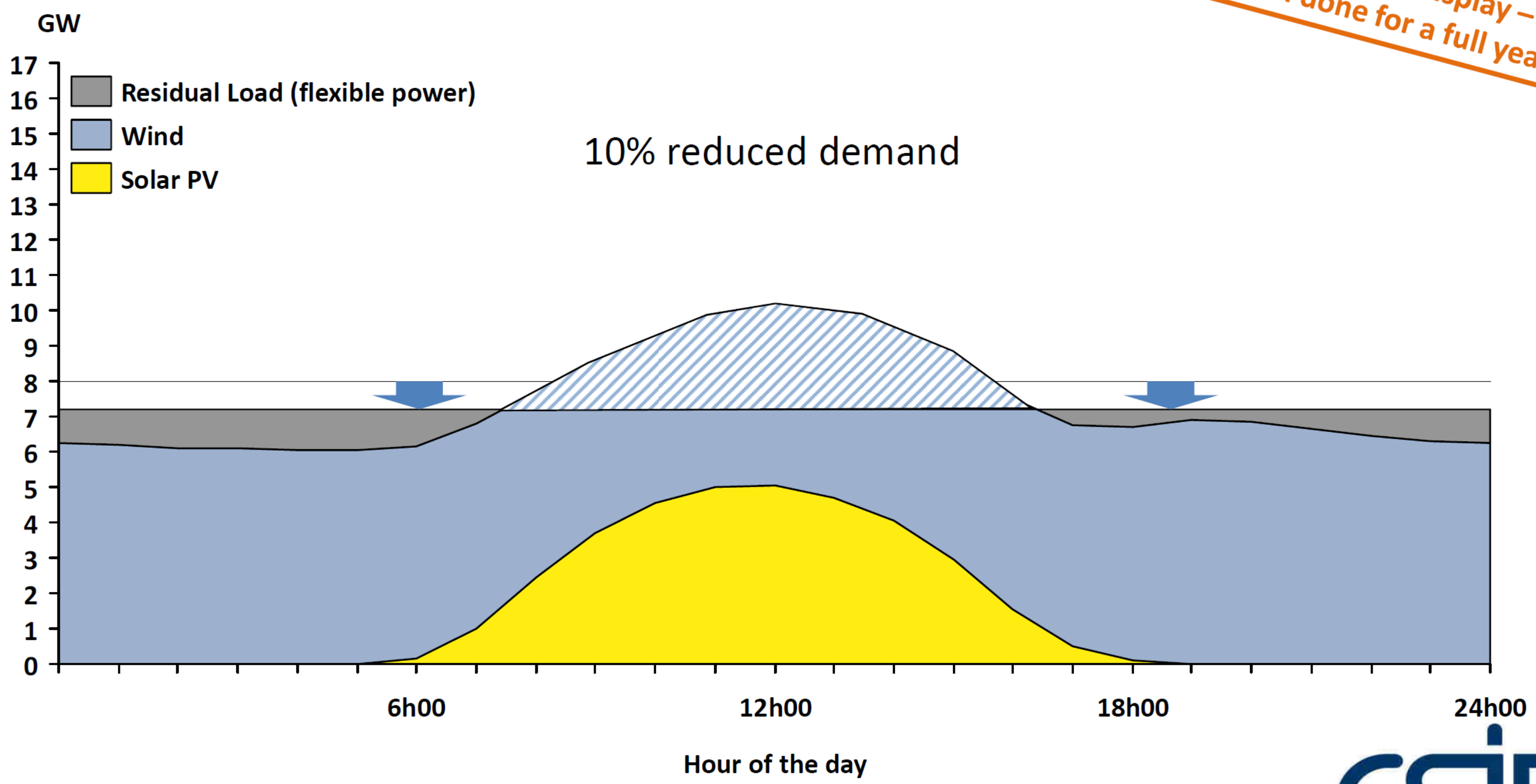
10% less load: excess energy increases, need for flexible power reduces

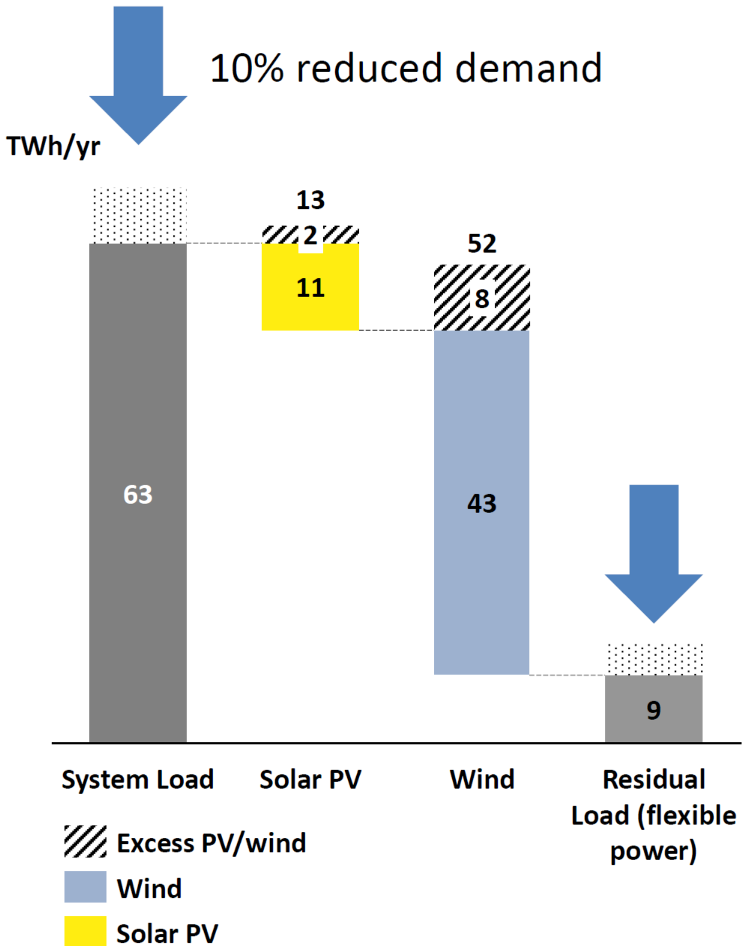
Average hourly solar PV and wind power supply calculated from simulation for the entire year

"Average day" in display – simulation done for a full year



Sources: CSIR analysis

Low sensitivity to changes in demand (-10%): unit cost stays constant



Sources: CSIR analysis

13 TWh/yr * 0.82 R/kWh
+ 52 TWh/yr * 0.65 R/kWh
+ ~~13~~ 9 TWh/yr * ~~2.0~~ 2.2 R/kWh
——————————————— = 1.0~~1~~2 R/kWh
~~70~~ 63 TWh/yr

- No value given to 7 TWh/yr of excess energy (bought and "thrown away")
- Bid Window 4 costs for PV/wind (no further cost reduction assumed)
- Very high cost for flexible power of 2.2 R/kWh assumed

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Conclusions

- The study assumed no coal-fired fleet, and a constant baseload
- The South African reality is a large installed coal-fired base, at varying stages of plant life (Medupi and Kusile coming online, others will be approaching end of life), and a morning and evening peak not well addressed by PV, particularly in winter.
- The study assumed variable supply to be gas-based, with high fuel cost. If CSP were to make a significant contribution to variable supply, the variable O&M costs would be low and the fixed costs high. Different optimal positions may be found.
- Pierce (2013) found that solar augmentation of coal-fired power stations would be 72% the costs of a stand-alone CSP plant (suggesting R2/kWh for CSP costs of R2.8/kWh). Eskom internal studies suggest that solar augmentation of Eskom power stations would be cheaper than R2/kWh.
- Eskom CEO Brian Molefe said in May that “Renewables have disappointed us. Renewable energy has failed to provide the required energy when Eskom needed it the most.” How can we prove this wrong in the future?

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Thank you

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