Can renewables supply baseload?

Presentation at the workshop Economics of Nuclear

Dr Tobias Bischof-Niemz, CSIR Energy Centre Manager

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Cell: +27 83 403 1108
Email: TBischofNiemz@csir.co.za

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Dr Tobias Bischof-Niemz

Head of CSIR's Energy Centre

Professional Experience

- Member of the Ministerial Advisory Council on Energy (MACE)
- Extraordinary Associate Professor at Stellenbosch University
- Jul 2014 – today: Centre Manager at the CSIR, responsible to lead the establishment of an integrated energy research centre

- 2012 – 2014: PV/Renewables Specialist at Eskom in the team that developed the IRP; afterwards 2 months contract work in the DoE's IPP Unit on gas, coal IPP and rooftop PV

- 2007 – 2012: Senior consultant (energy system and renewables expert) at The Boston Consulting Group, Berlin and Frankfurt, Germany

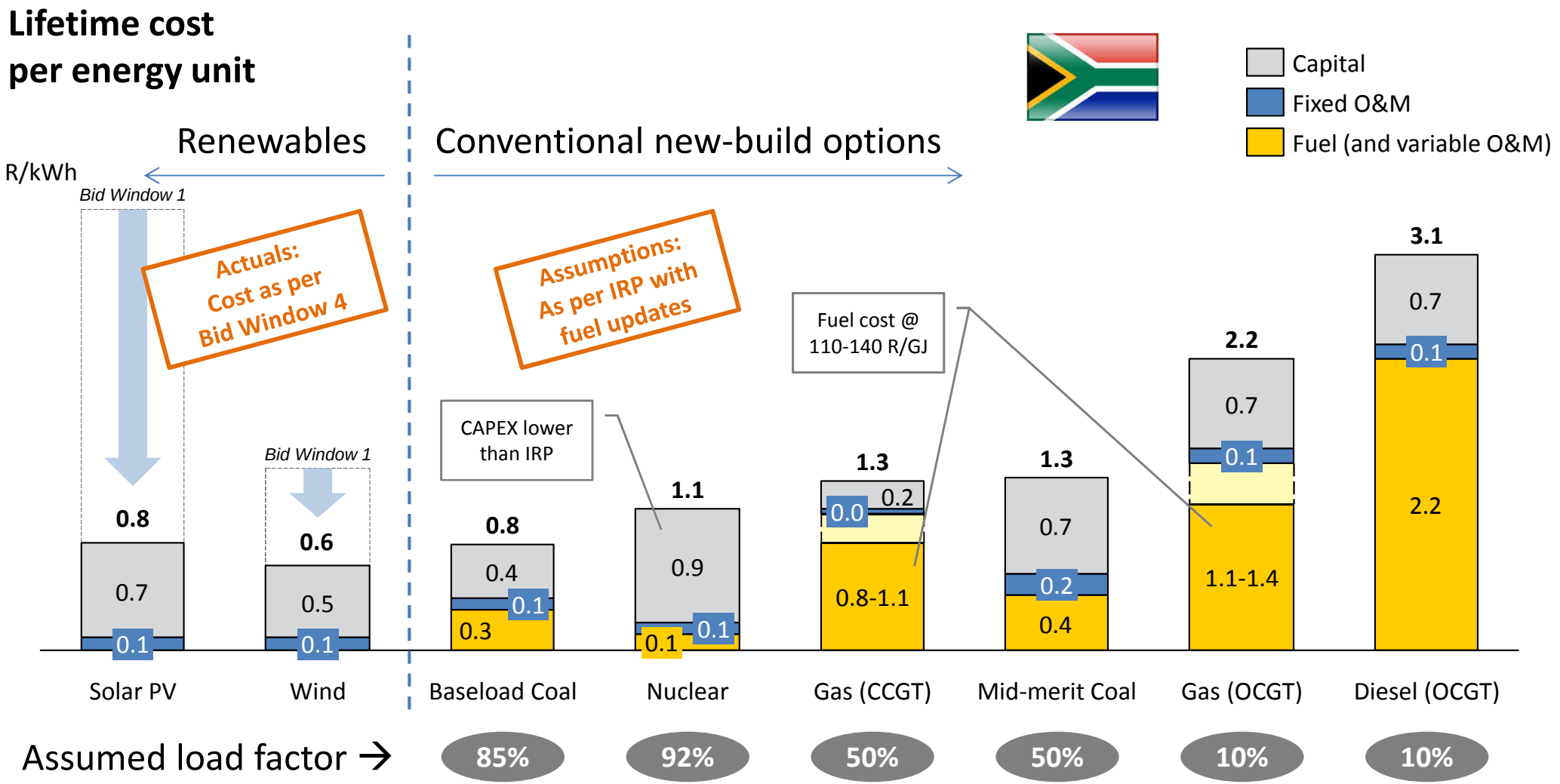
Education

- Master of Public Administration (MPA) on energy and renewables policies in 2009 from Columbia University in New York City, USA

- PhD ("Dr.-Ing.") in 2006 in Automotive Engineering from TU Darmstadt, Germany

- Mechanical Engineering at Technical University of Darmstadt, Germany (Master – "Dipl.-Ing." in 2003) and at UC Berkeley, USA

Consequence of renewables' cost reduction for South Africa: Solar PV and wind are the cheapest new-build options per kWh today



Note: Changing full-load hours for conventionals drastically changes the fixed cost components per kWh (lower full-load hours → higher capital costs and fixed O&M costs per MWh); Assumptions: average efficiency for CCGT = 50%, OCGT = 35%; coal = 37%; nuclear = 33%; IRP cost from Jan 2012 escalated with CPI to Jan 2016; assumed EPC CAPEX inflated by 10% to convert EPC/LCOE into tariff; Sources: IRP Update; REIPPPP outcomes; StatsSA for CPI; Eskom financial reports on coal/diesel fuel cost; CSIR analysis

Thought experiment: Build a new power system from scratch

Base load: **8 GW**

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

Can a blend of wind and solar PV, mixed with flexible dispatchable power to fill the gaps supply this?

If yes, at what cost?

Assumptions/approach

- 15 GW wind @ 0.65 R/kWh (Bid Window 4 average tariff in Apr-2015-Rand)
- 7 GW solar PV @ 0.82 R/kWh (Bid Window 4 average tariff in Apr-2015-Rand)
- 8 GW flexible power generator to fill the gaps @ 2.0 R/kWh
- Hourly solar PV and wind data from recent CSIR study, covering the entire country
- Hourly simulation of supply structure for an entire year

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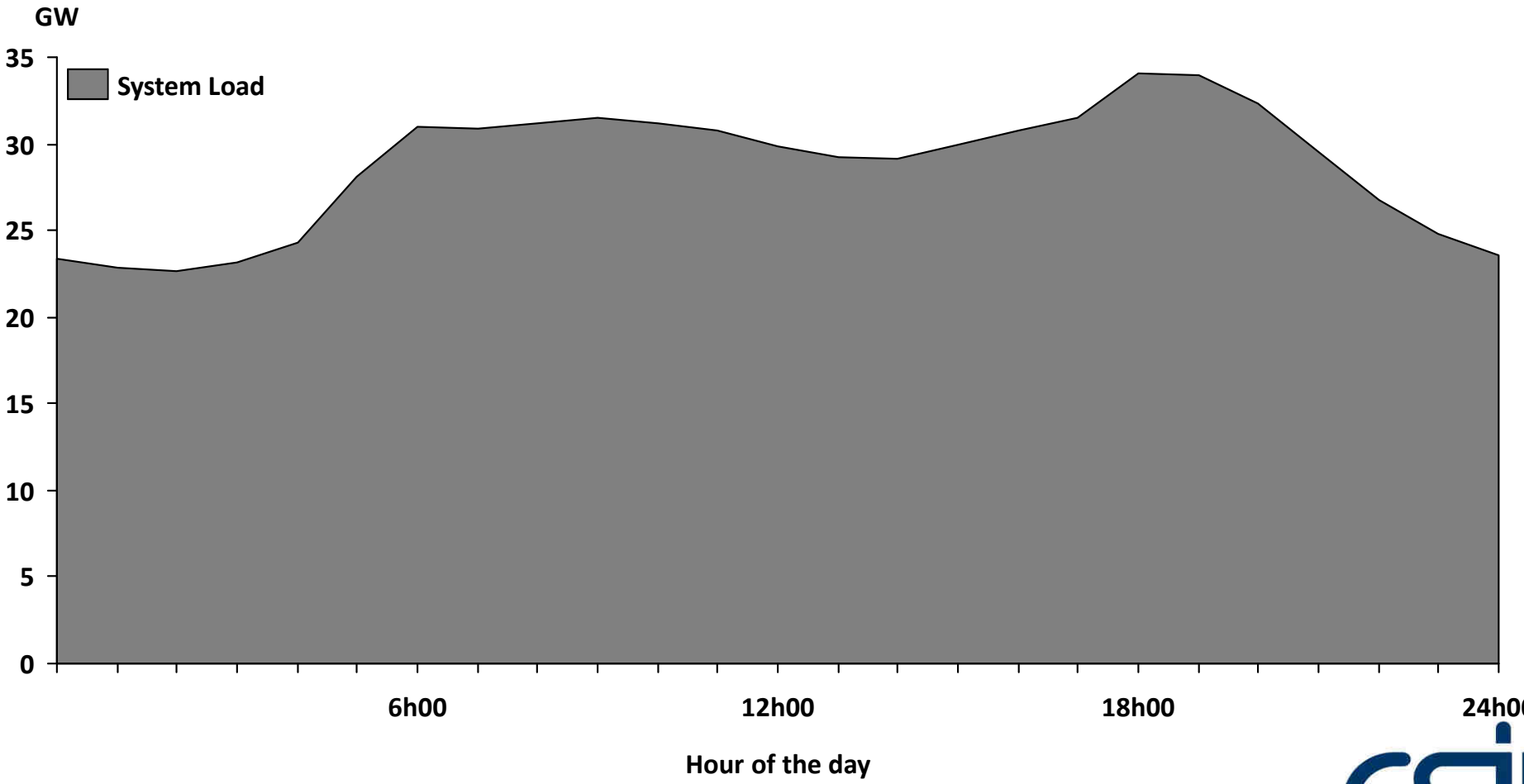
Sources: CSIR analysis

Side note: System load does not have “baseload” profile

Actual system load in the South African power system on 28 July 2015



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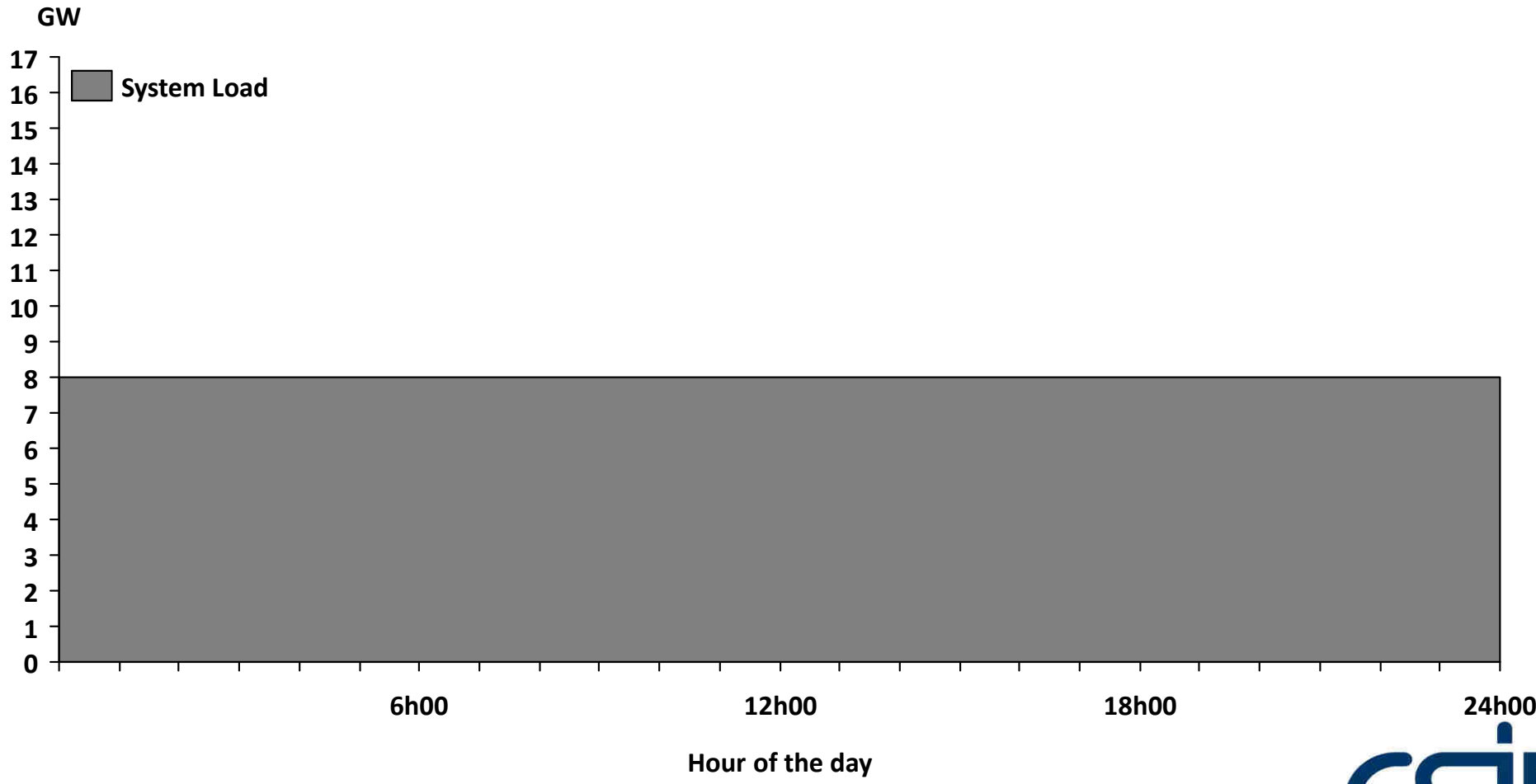
Sources: CSIR analysis

Thought experiment: assumed 8 GW of true baseload



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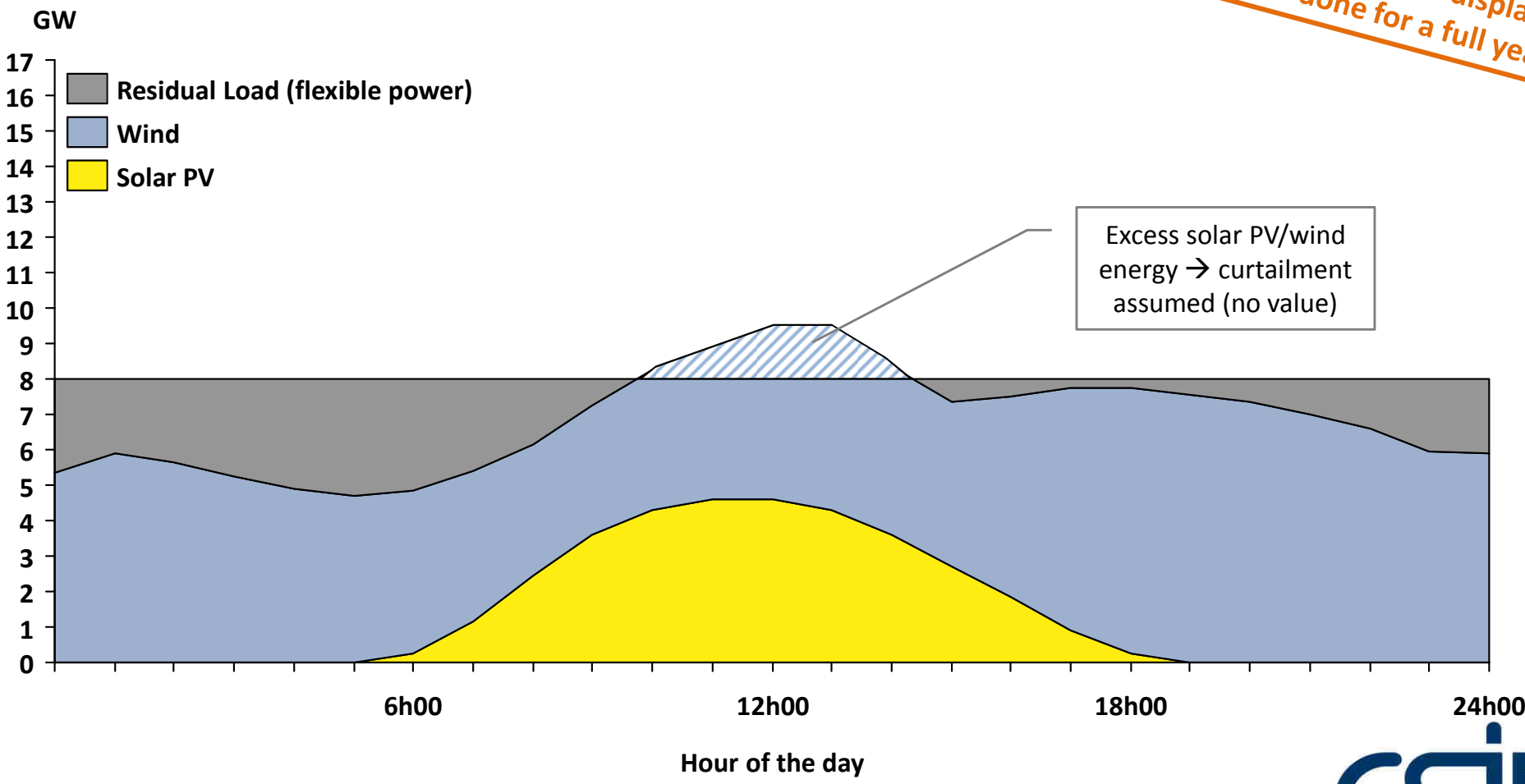
Sources: CSIR analysis

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

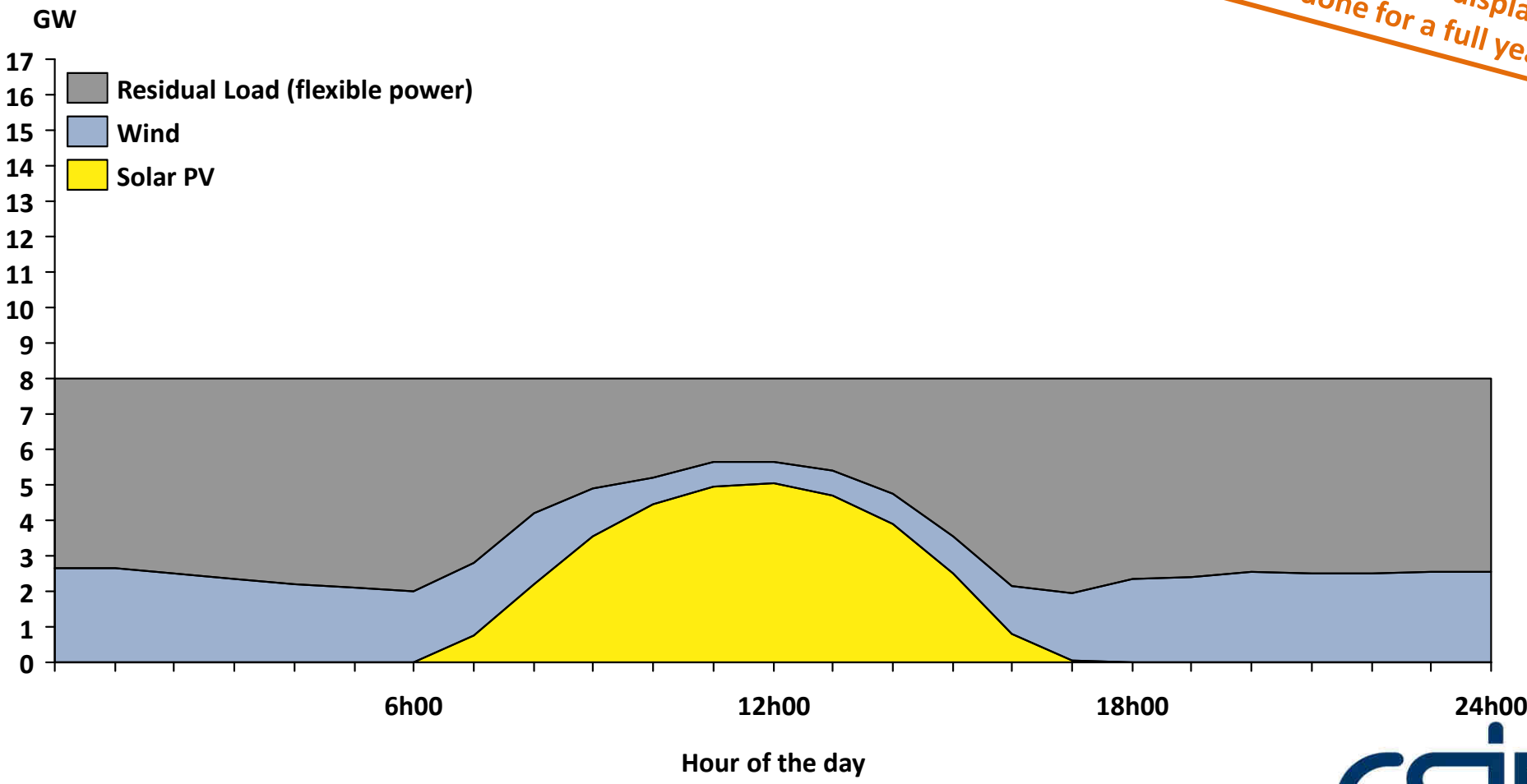


Sources: CSIR analysis

On a low-sun, 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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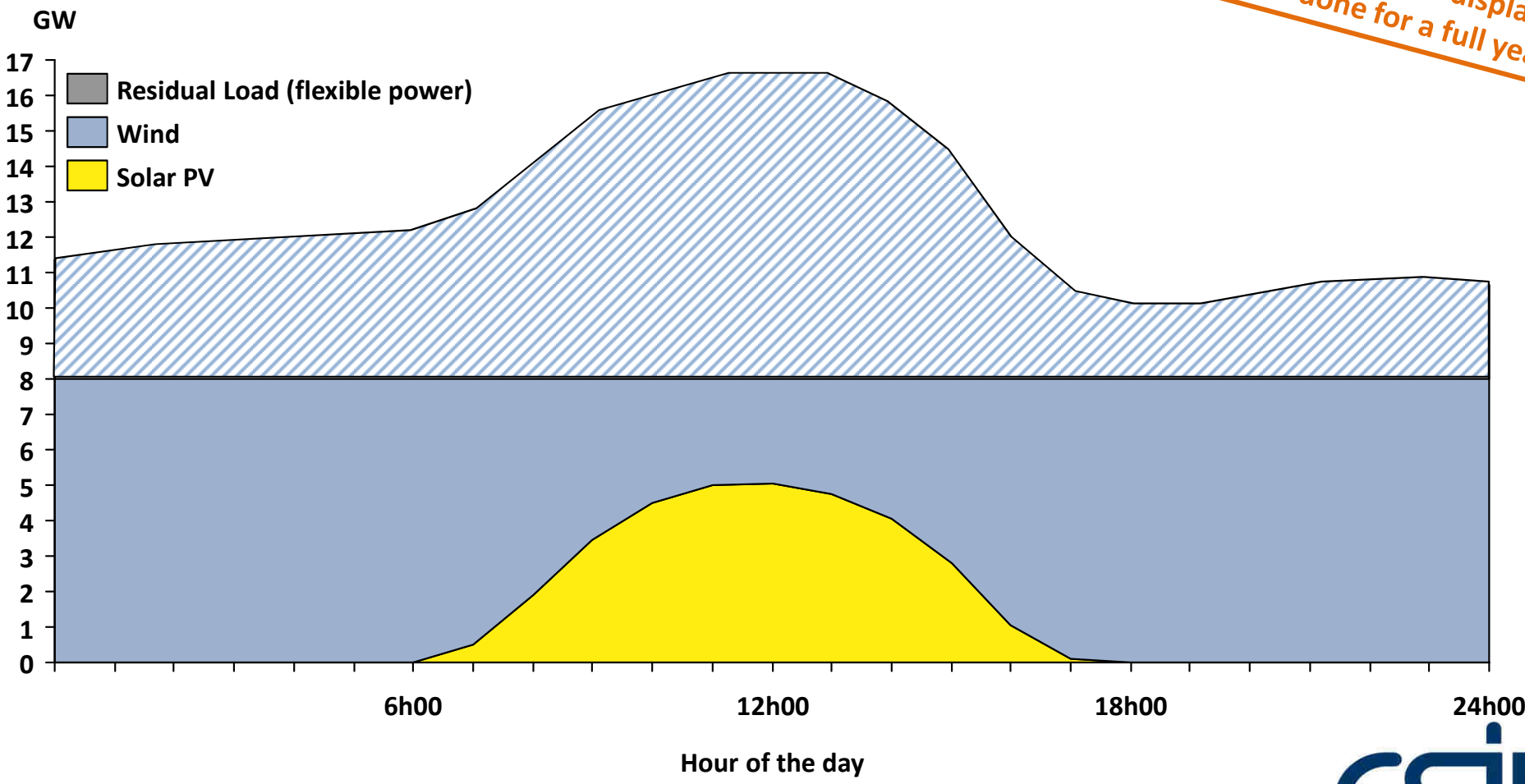
Sources: CSIR analysis

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

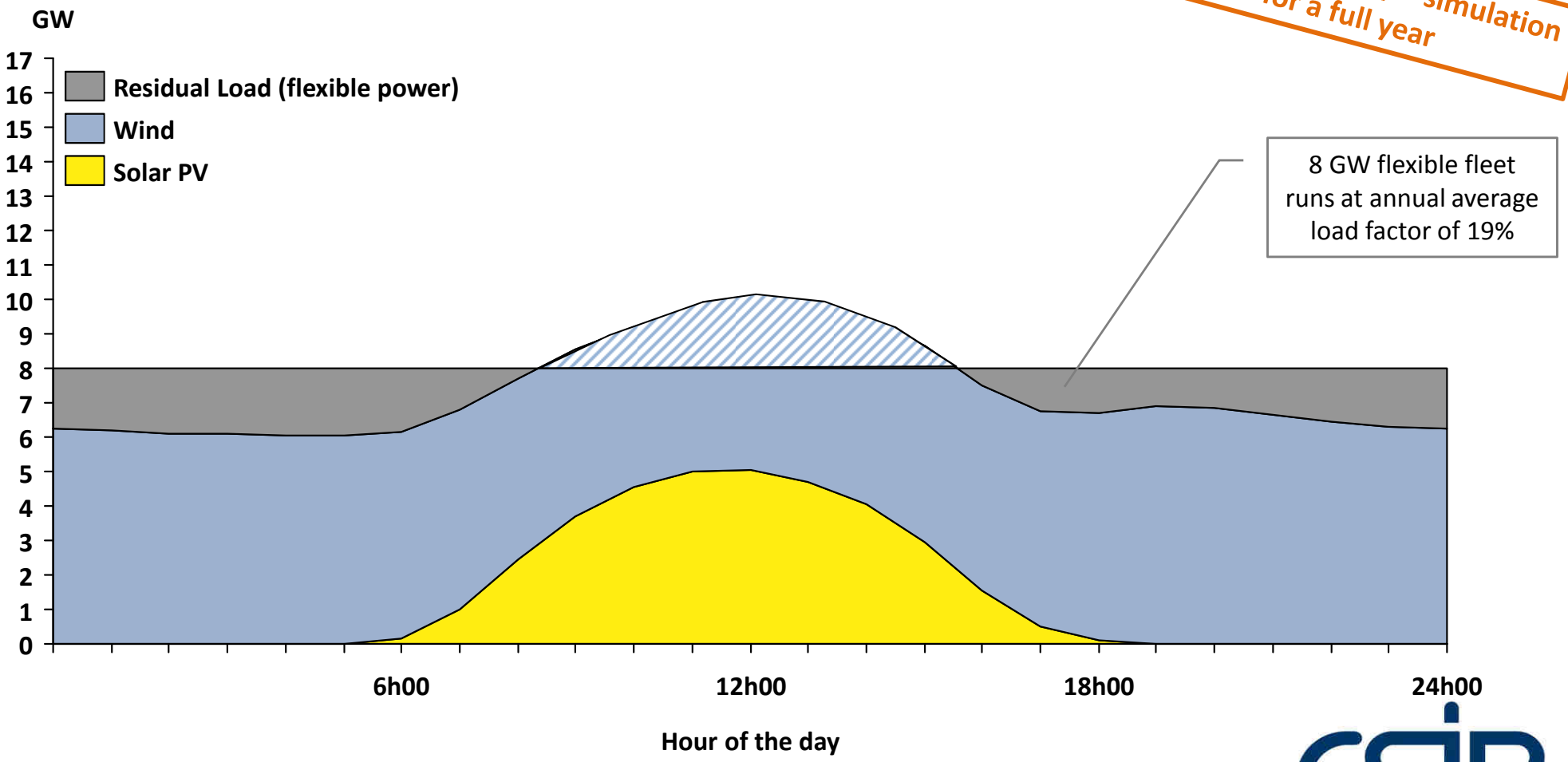


Sources: CSIR analysis

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

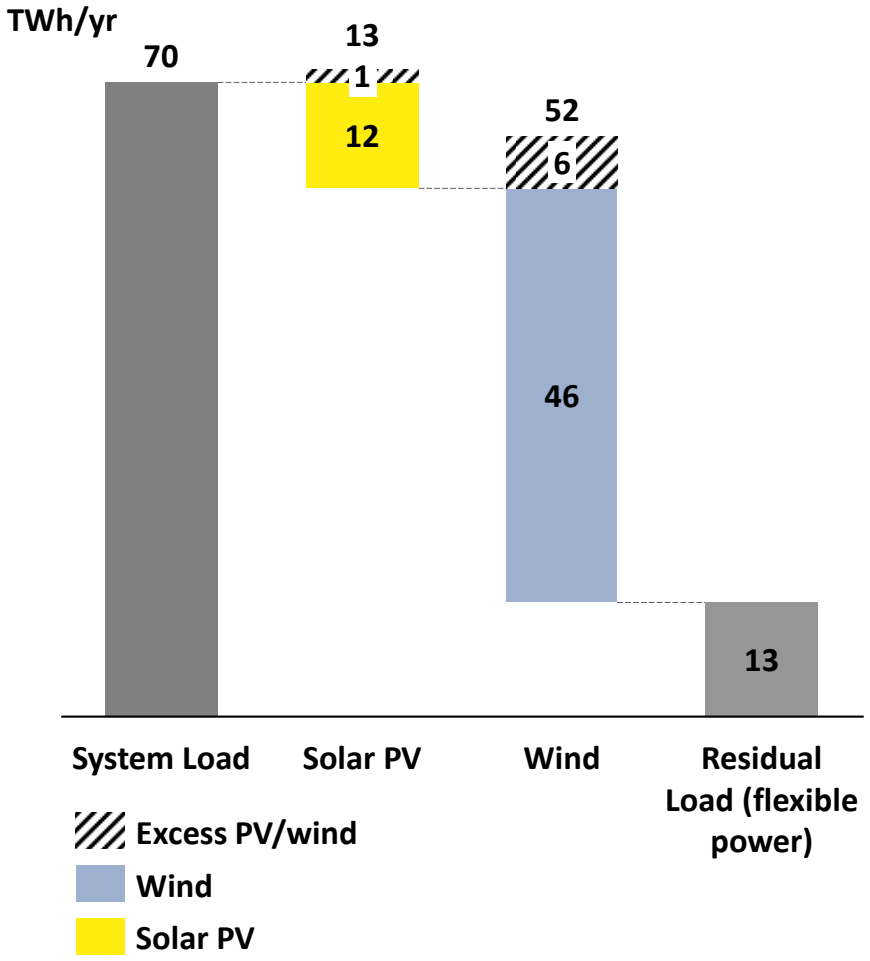
Average hourly solar PV and wind power supply calculated from simulation for the entire year

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



Sources: CSIR analysis

The mix of solar PV, wind and flexible power costs 1 R/kWh – same level as alternative new-build options that supply baseload



$$\frac{13\ \text{TWh/yr} * 0.82\ \text{R/kWh} + 52\ \text{TWh/yr} * 0.65\ \text{R/kWh} + 13\ \text{TWh/yr} * 2.00\ \text{R/kWh}}{70\ \text{TWh/yr}} = 1\ \text{R/kWh}$$

- 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 2.0 R/kWh assumed

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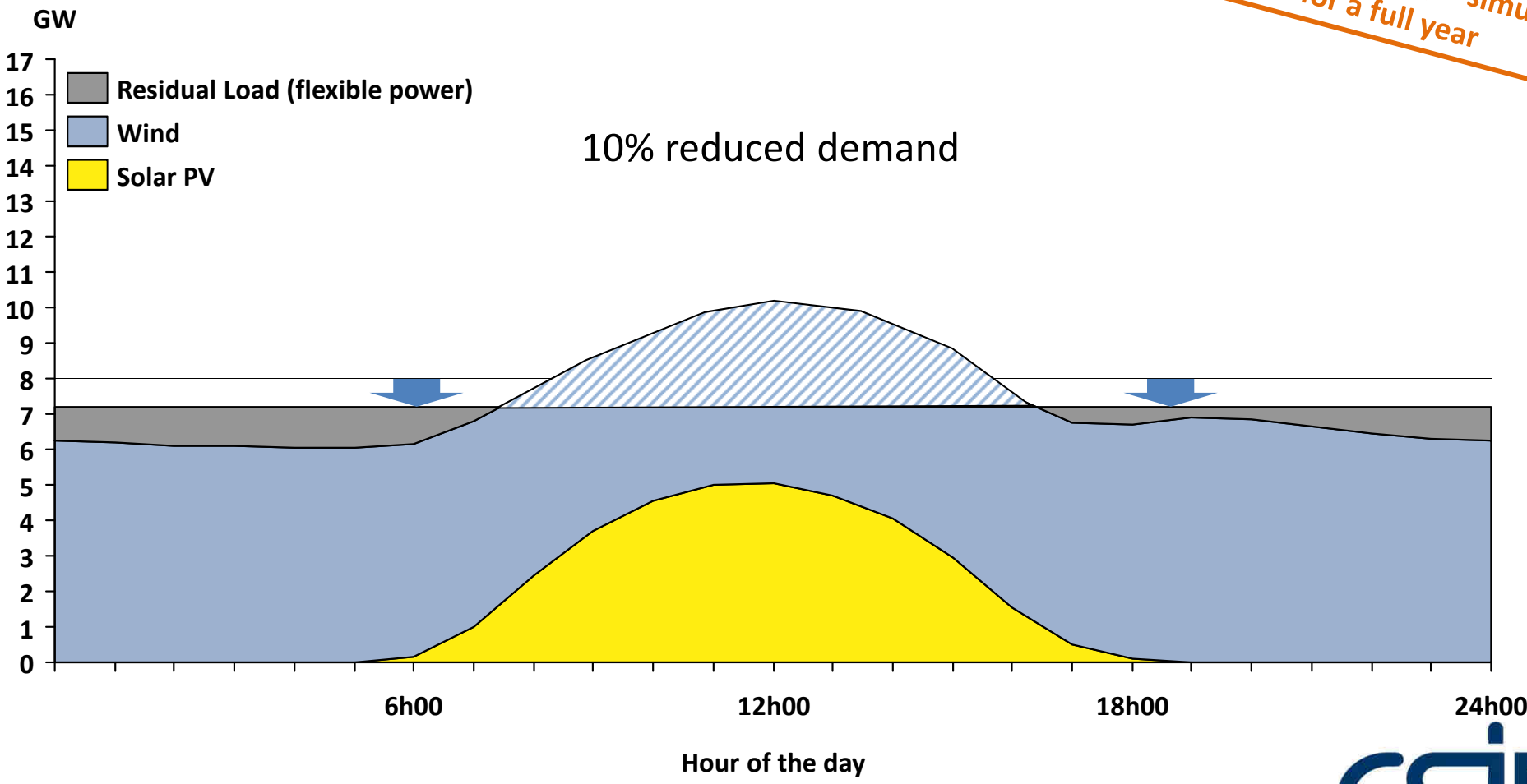
Sources: CSIR analysis

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

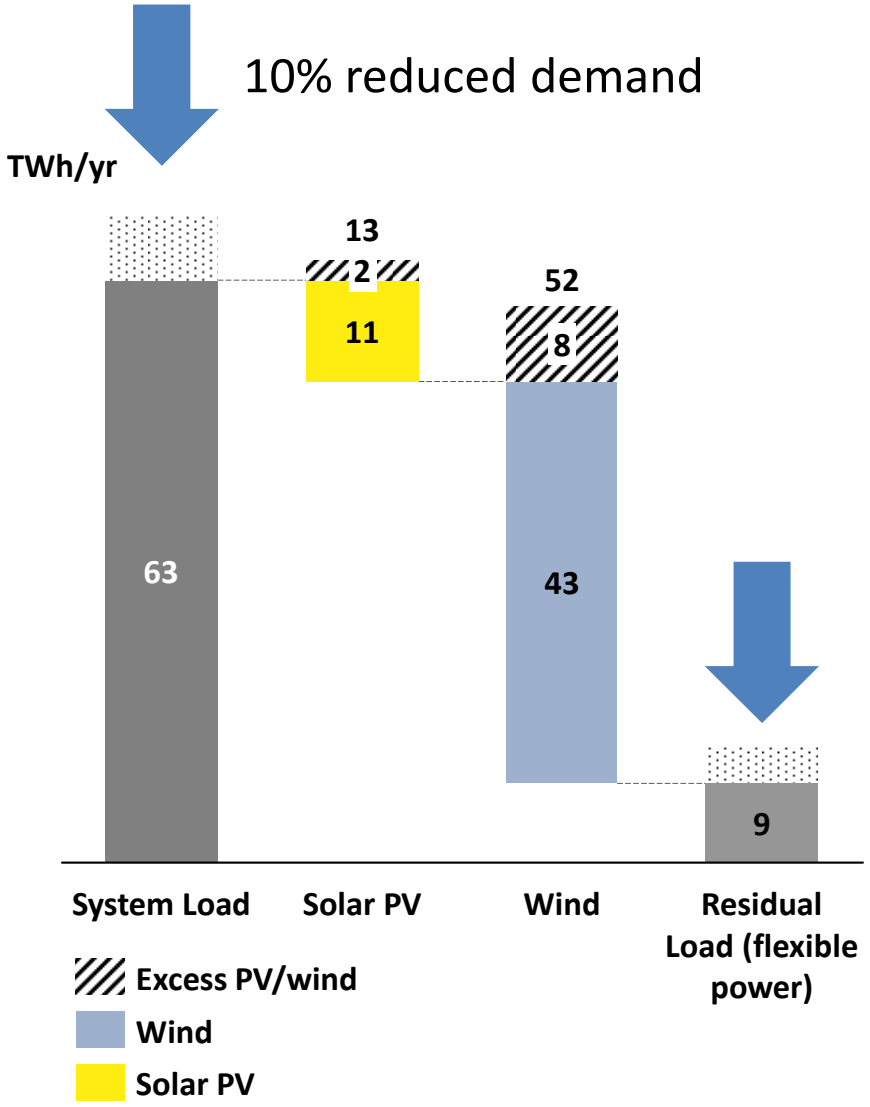
Average hourly solar PV and wind power supply calculated from simulation for the entire year

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



Sources: CSIR analysis

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



13 TWh/yr * 0.82 R/kWh
+ 52 TWh/yr * 0.65 R/kWh
+ ~~13~~ 9 TWh/yr * ~~2.00~~ 2.10 R/kWh

———————————————— = 1 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 2.0 R/kWh assumed

Sources: CSIR analysis

Thank you!