Implications of renewables on energy planning

Presentation at the SAIREC 2015

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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

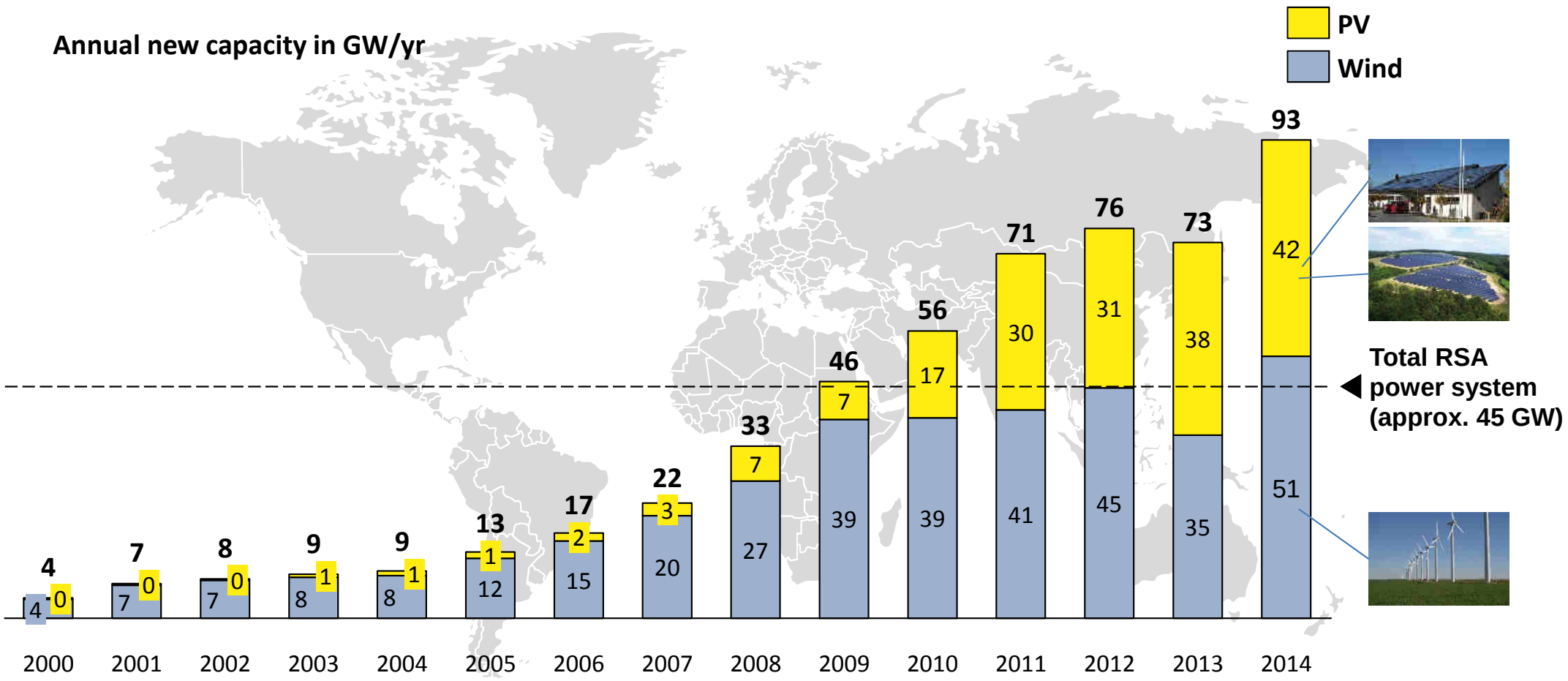
- Master of Public Administration (MPA) on energy and renewables policies in 2009 from Columbia University in New York City, USA

- 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

The Context

In 2014, 93 GW of wind and PV were newly installed globally

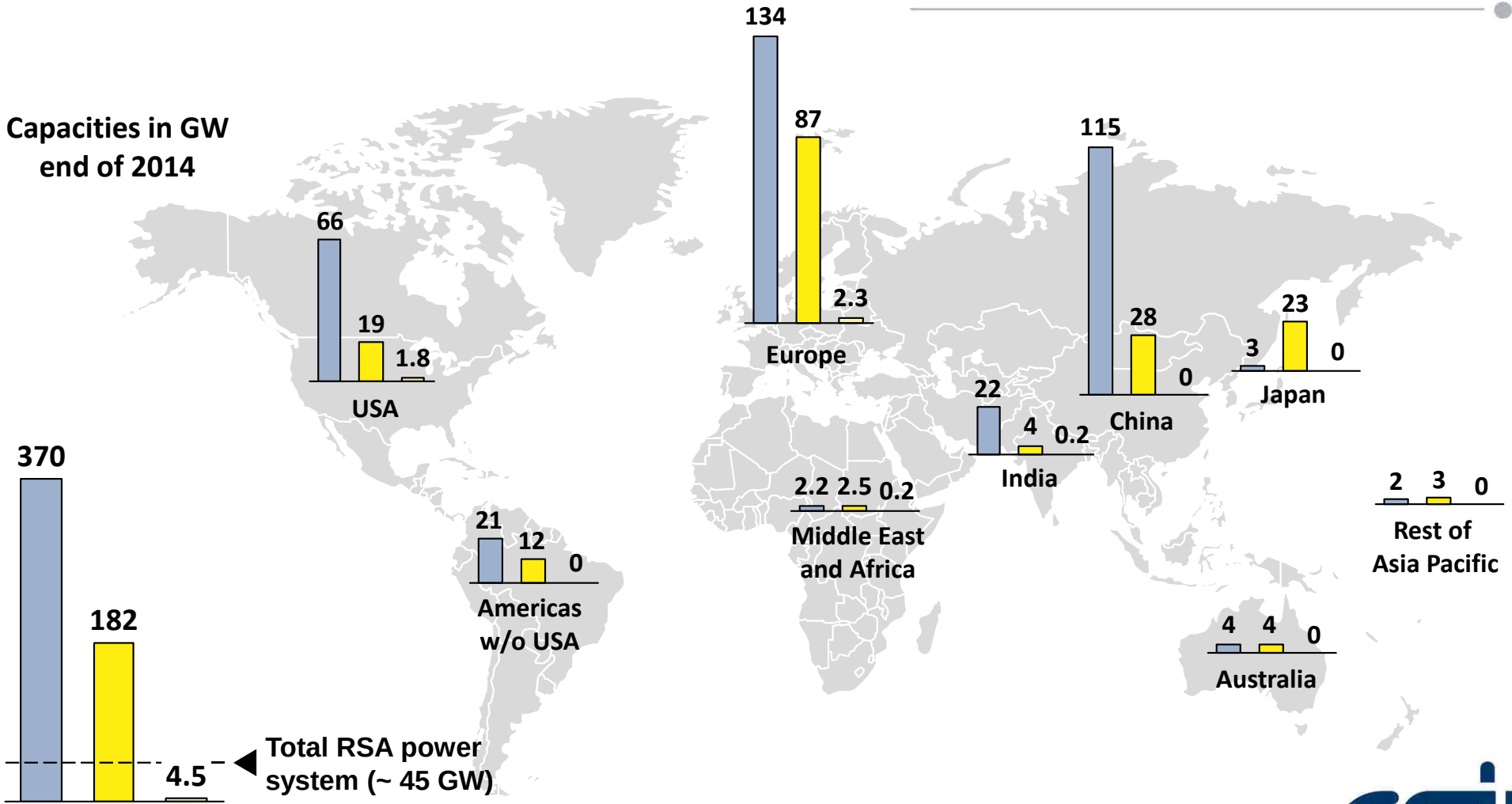


This is all very new: Almost 90% of the globally existing PV capacity was installed during the last five years alone!

Sources: International Energy Outlook of the EIA; GWEC; EPIA; CSIR analysis

Renewables until today mainly driven by US, Europe and China

Globally installed capacities for three major renewables wind, PV and CSP end of 2014

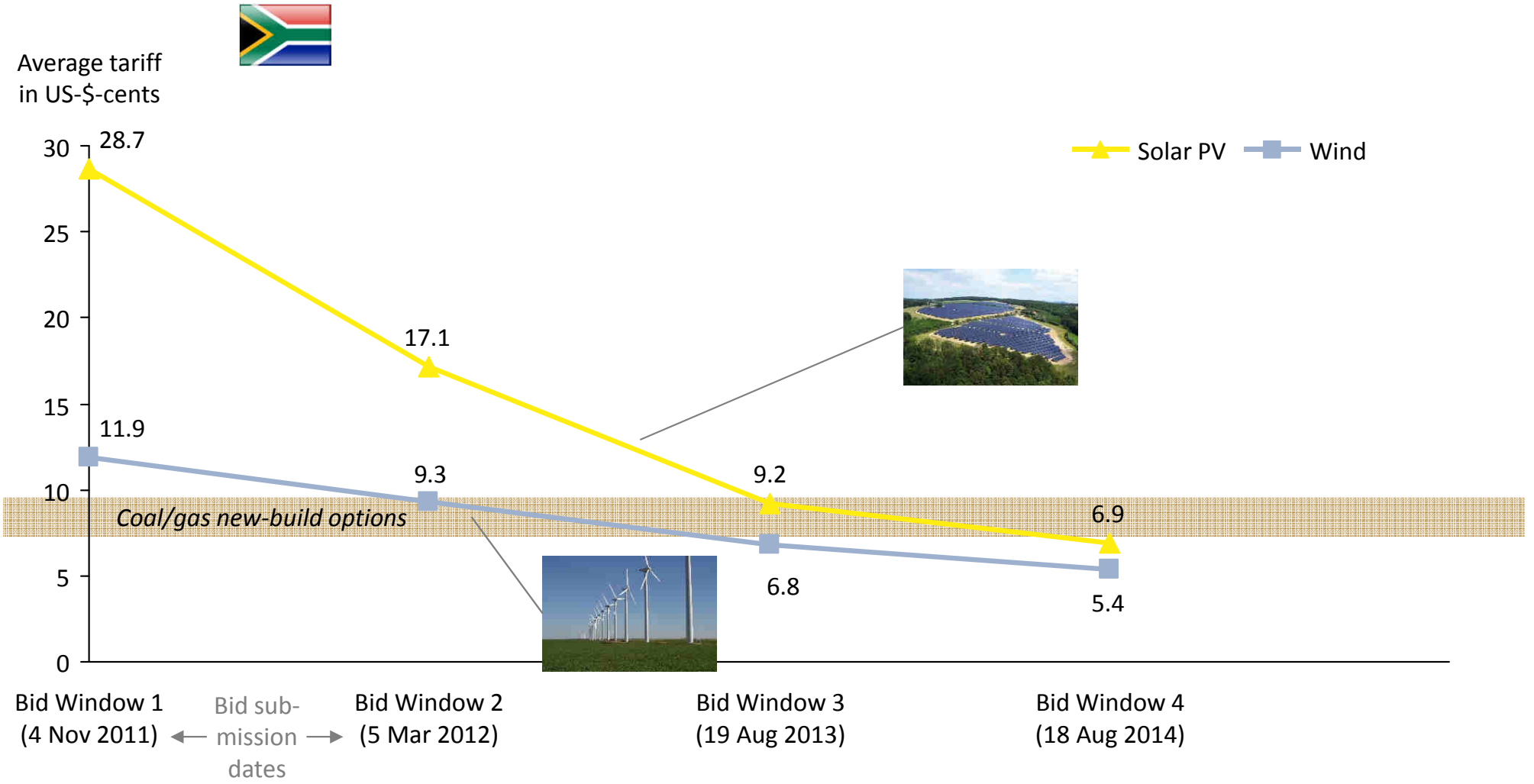


Large amounts of subsidies were spent, that brought costs down and new solar PV and wind are now cost competitive

Sources: GWEC; EPIA; CSPToday; CSIR analysis

Actual results: solar PV & wind in South Africa cost competitive today

First four bid windows' results of Department of Energy's RE IPP Procurement Programme (REIPPPP)



Notes: For CSP Bid Window 3, the weighted average of base and peak tariff is indicated, assuming 50% annual load factor

Sources: StatsSA on CPI; Department of Energy's publications on results of first four bid windows http://www.energy.gov.za/IPP/List-of-IPP-Preferred-Bidders-Window-three-04Nov2013.pdf; http://www.energy.gov.za/IPP/Renewables_IPP_ProcurementProgram_WindowTwoAnnouncement_21May2012.pptx; http://www.ipprenewables.co.za/gong/widget/file/download/id/279; CSIR analysis

Consequence of renewables' cost reduction: Solar PV & wind cheapest new-build options per kWh in South Africa

Lifetime cost per energy unit

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 May 2015; assumed EPC CAPEX inflated by 10% to convert EPC/LCOE into tariff; CSP: 50% annual load factor and full utilisation of the five peak-tariff hours per day assumed to calculate weighted average tariff from base and peak tariff
Sources: IRP Update; REIPPPP outcomes; StatsSA for CPI; Eskom financial reports on coal/diesel fuel cost; CSIR analysis

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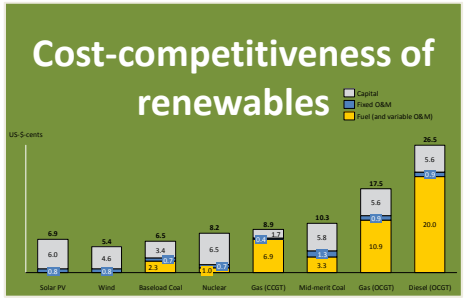
The New Energy World

Cost competitiveness of renewables has two consequences



I

Distributed Power Generation

Because renewables are inherently smaller and more distributed than conventionals

II

System Planner's / Operator's Paradigm Shift

Because the two mainstream renewables solar PV and wind are dispatched by the weather, and not by the System Operator

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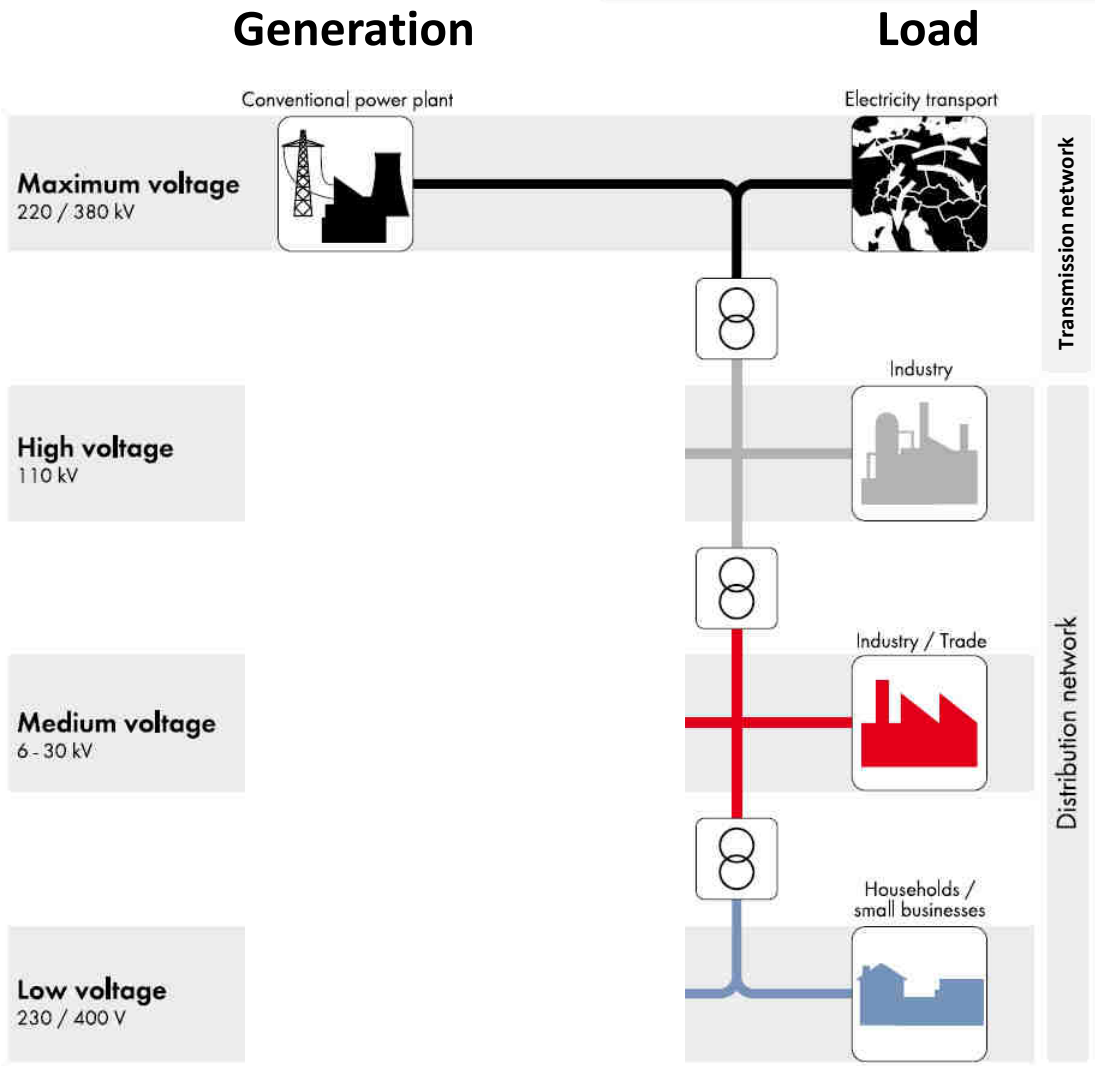
I Today: production and balancing of supply/demand happens centrally

Today's system architecture



Balancing of supply/demand on central system level

One-directional power flow

On end-consumer level mostly no generation, no storage/balancing capabilities, no manageable load

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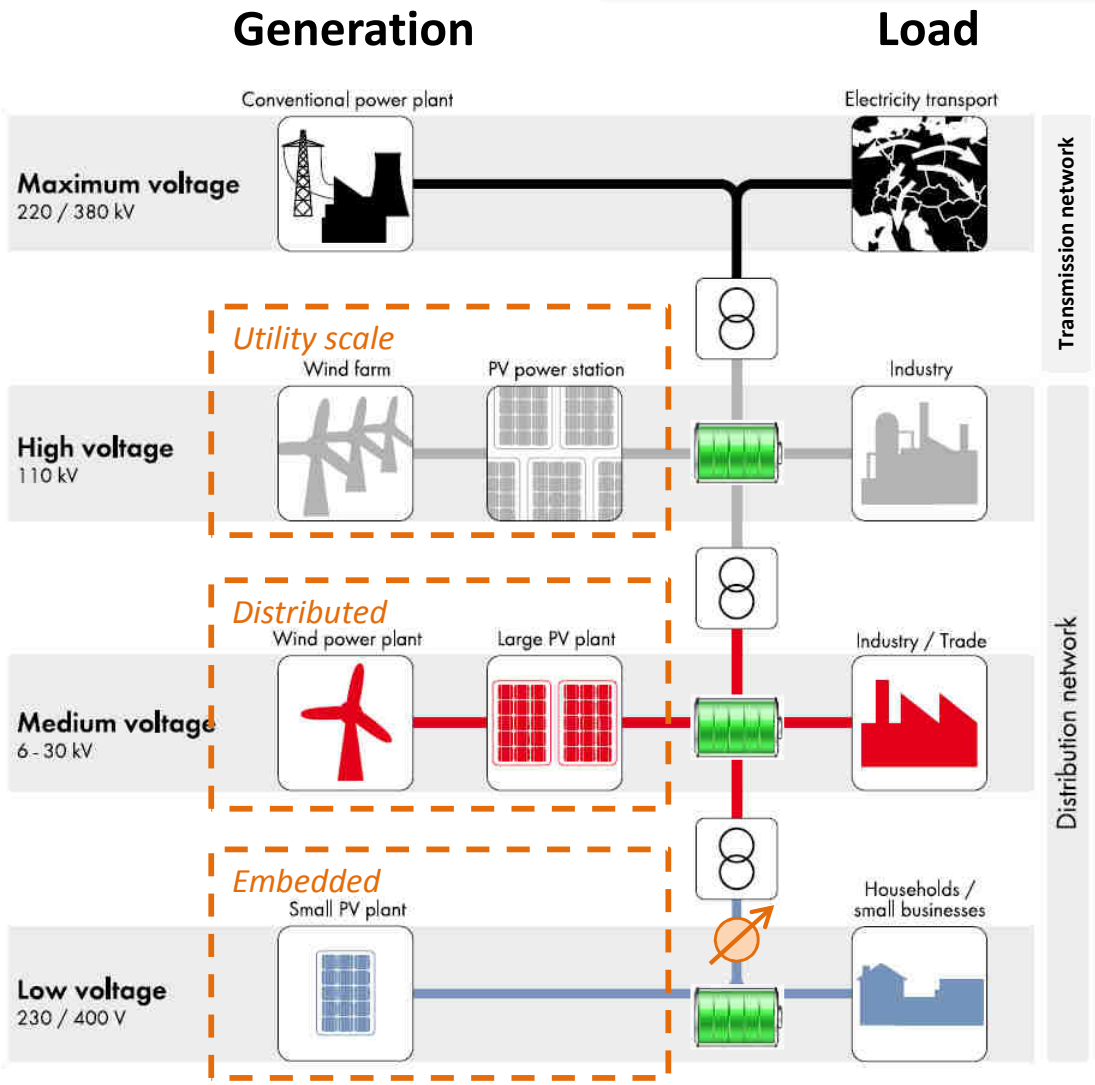
Sources: SMA; CSIR analysis

Future: Production and consumption occurs on all levels, power flows are bi-directional, an ICT layer is required on top of the energy layer

Future system architecture



Balancing of supply/demand managed on central system level, executed on all voltage levels

Bi-directional power flow

ICT layer on top of energy layer

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Sources: SMA; CSIR analysis

Thought experiment: Build a new power system from scratch

Annual demand: **11.1 TWh/yr (4-5% of today's South African demand)**

Base load: **1 GW**

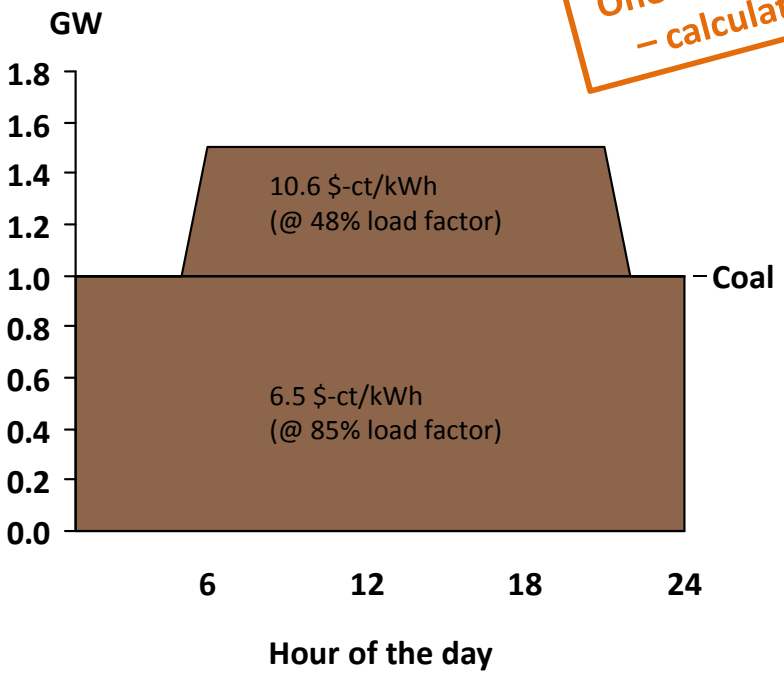
Day load: **1.3 GW in summer**
1.5 GW in winter

What is cheaper to supply that profile?

1) Base and mid-merit coal?
2) A blend of wind and solar PV, mixed with gas to fill the gaps?

A mix of new baseload-operated coal and new mid-merit coal costs 7.3 $-ct/kWh for the pure cost of power generation

One illustrative winter day in display – calculations done for a full year



Technology: Coal base / coal mid-merit
Size: 1.18 / 0.56 GW
Energy: 11.1 TWh/yr

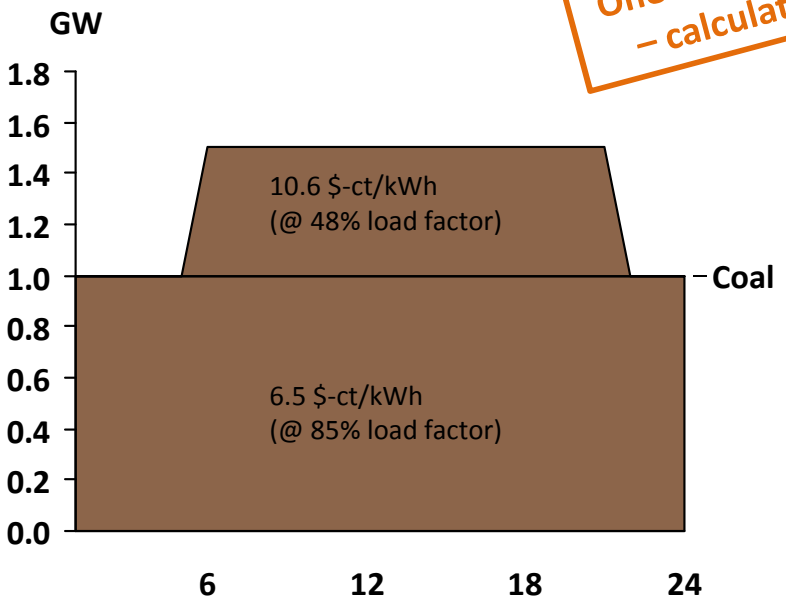
Weighted cost: **7.3 $-ct/kWh**

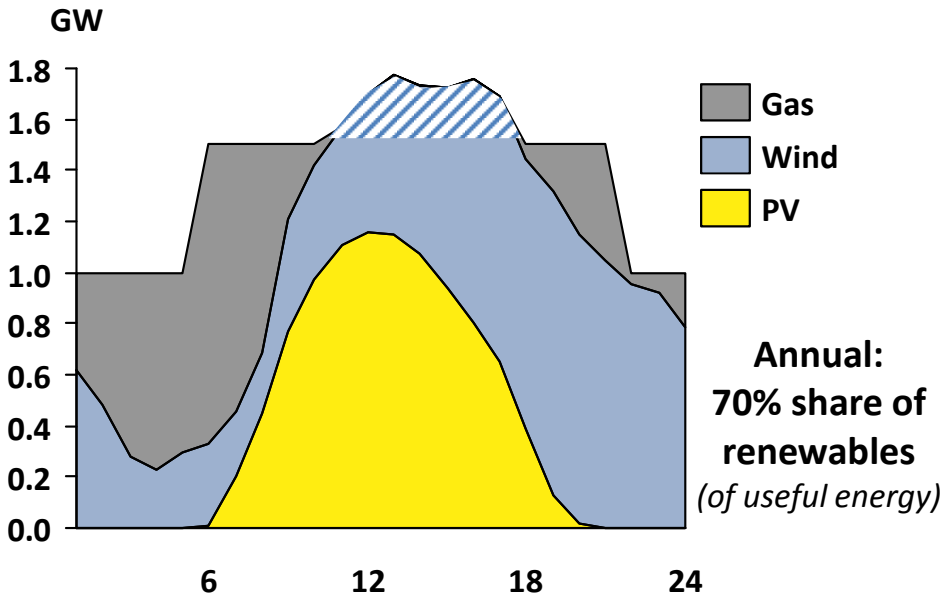
CO2: ~0.95 kg/kWh

A fully dispatchable mix of PV, wind and flexible gas can supply the demand similarly in the same reliable manner as the coal mix

II

One illustrative winter day in display – calculations done for a full year





Annual:
70% share of renewables
(of useful energy)

Technology: Coal base / coal mid-merit
Size: 1.18 / 0.56 GW
Energy: 11.1 TWh/yr

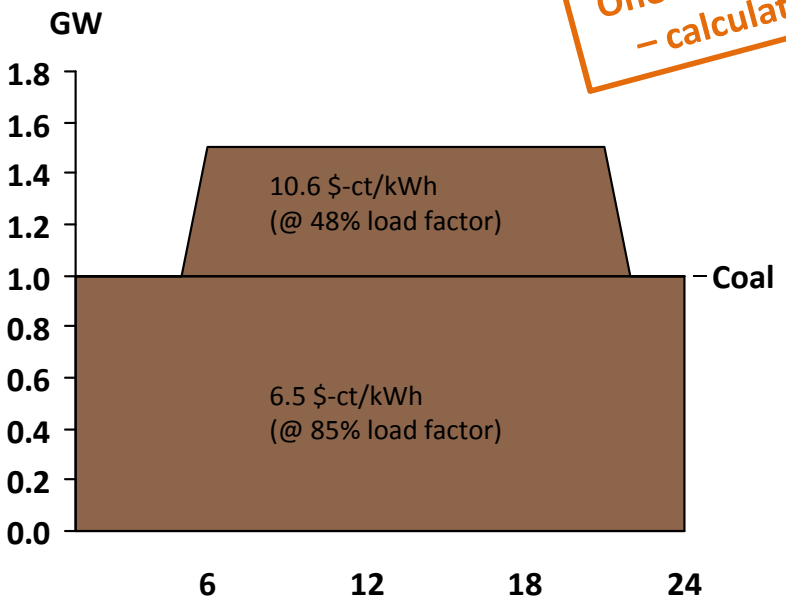
Weighted cost: **7.3 $-ct/kWh**

CO2: ~0.95 kg/kWh

By 2020, a mix of PV, wind and flexible gas (LNG-based) costs the same as new coal, even without any value given to excess wind/PV energy

II

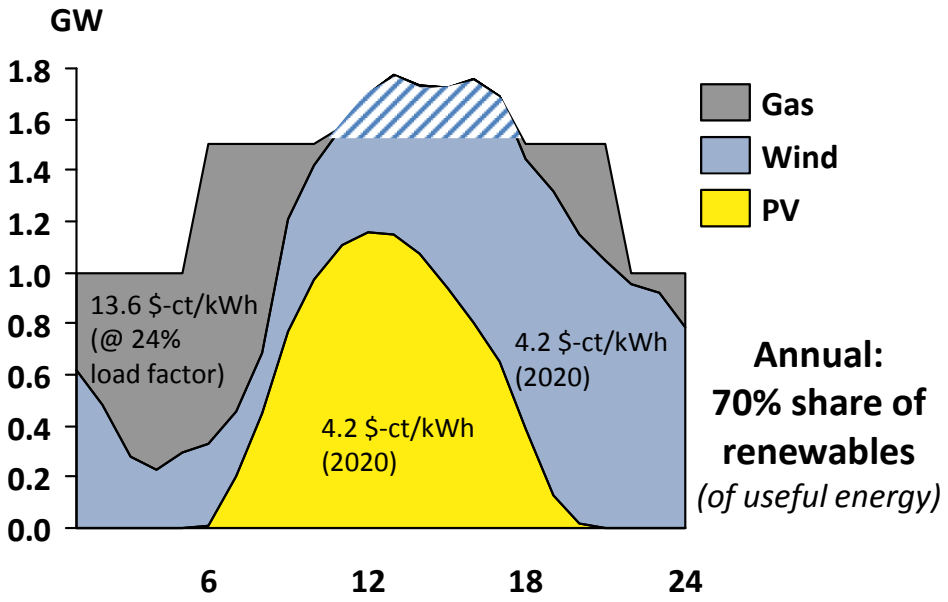
One illustrative winter day in display – calculations done for a full year



Technology: Coal base / coal mid-merit
Size: 1.18 / 0.56 GW
Energy: 11.1 TWh/yr

Weighted cost: **7.3 $-ct/kWh**

CO2: ~0.95 kg/kWh



Annual:
70% share of renewables
(of useful energy)

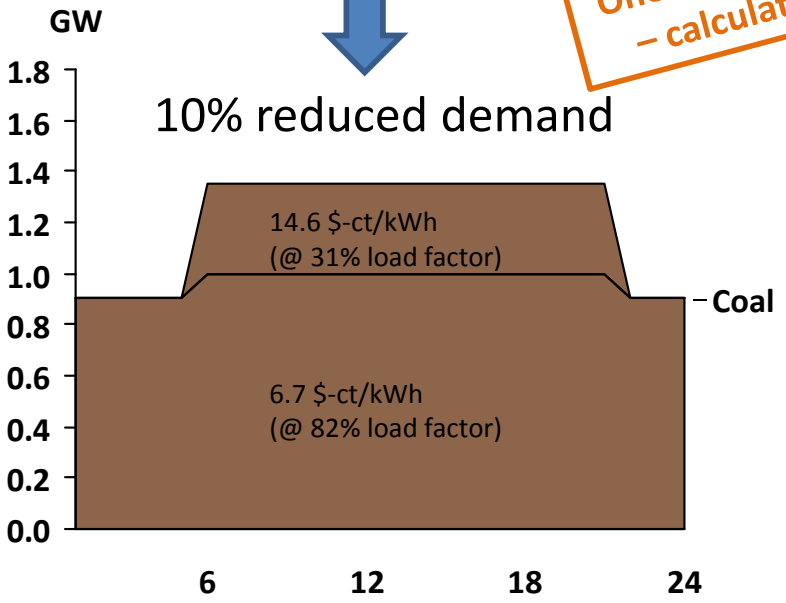
Technology: PV / wind / gas
Size: 1.5 / 2.0 / 1.61 GW
Energy (useful): 11.1 TWh/yr
Energy (total): 3.6 / 5.3 / 3.2 TWh/yr = 12.1 TWh/yr

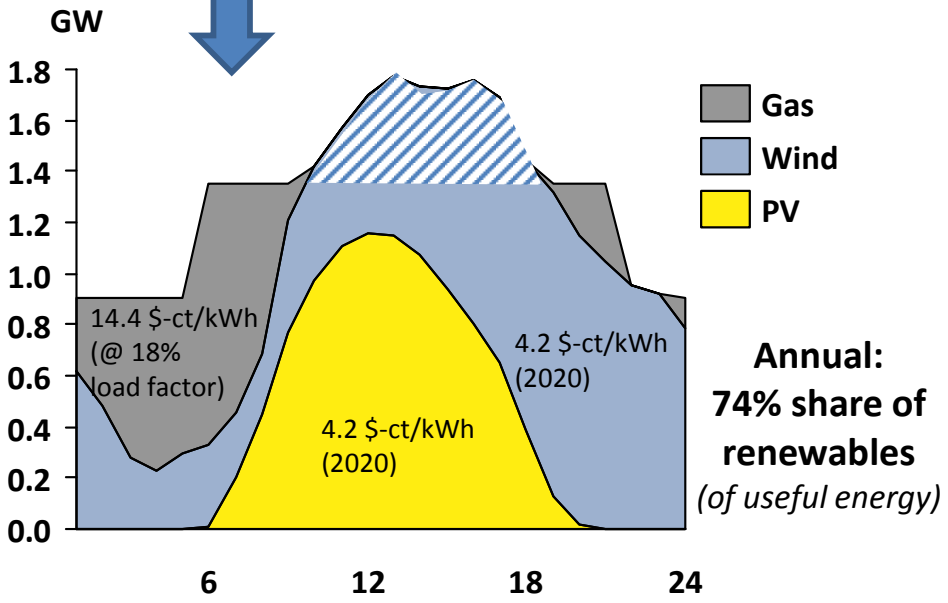
Weighted cost: **7.3 $-ct/kWh**
(per useful energy, i.e. no value given to excess)

CO2: ~0.18 kg/kWh (per useful energy)

In addition, the cost of a PV / wind / gas power plant scale more with reduced demand and thus unit cost per kWh stay more or less constant

One illustrative winter day in display – calculations done for a full year





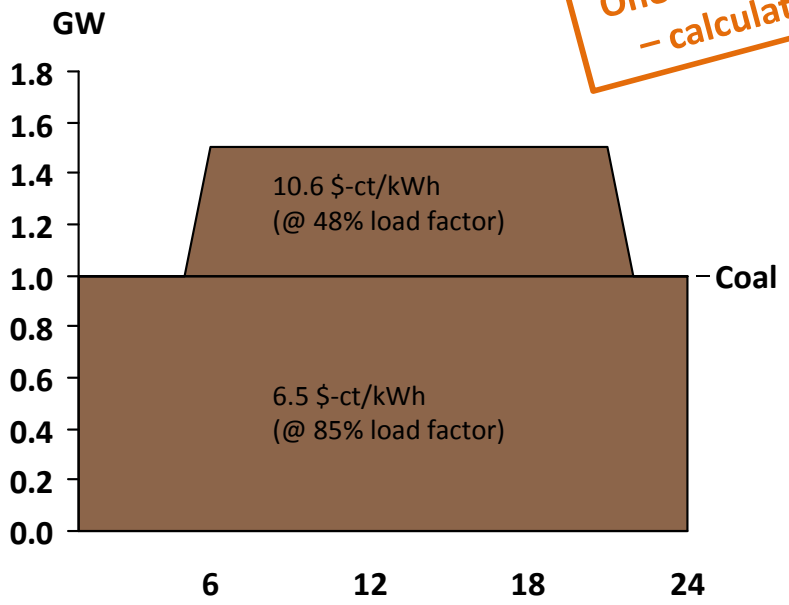
Annual: 74% share of renewables
(of useful energy)

Technology:	Coal base / coal mid-merit
Size:	1.18 / 0.56 GW
Energy:	10.0 TWh/yr
Weighted cost:	**7.8 $-ct/kWh** (plus 7%)
CO2:	~0.95 kg/kWh

Technology:	PV / wind / gas
Size:	1.5 / 2.0 / 1.61 GW
Energy (useful):	10.0 TWh/yr
Energy (total):	3.6 / 5.3 / 2.5 TWh/yr = 11.4 TWh/yr
Weighted cost:	**7.3 $-ct/kWh** (constant) *(per useful energy, i.e. no value given to excess)*
CO2:	~0.16 kg/kWh (per useful energy)

In reality, flexible, dispatchable loads and/or storage would utilise the excess energy – if value is assigned to it, cost of useful energy go down

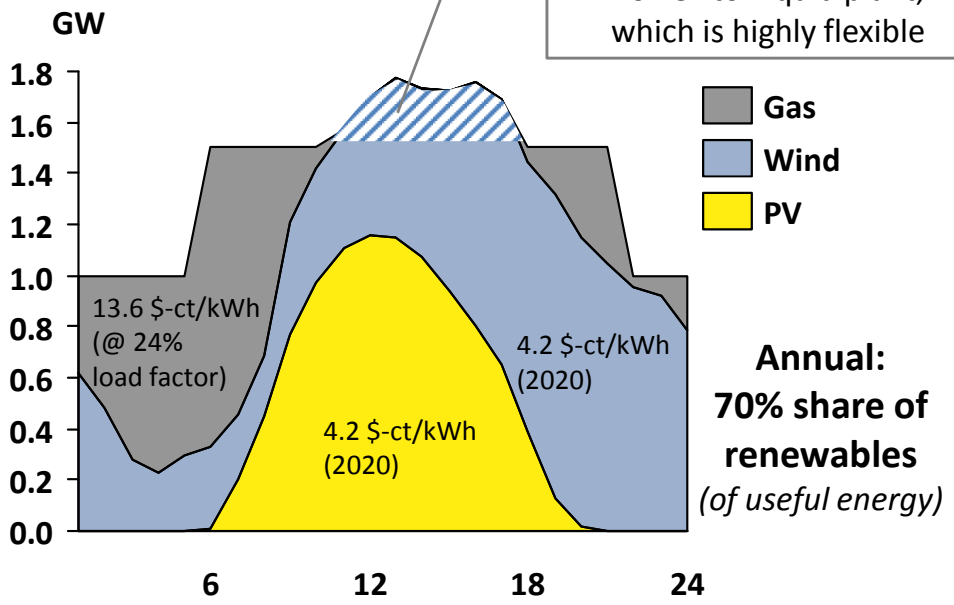
One illustrative winter day in display – calculations done for a full year



Technology: Coal base / coal mid-merit
Size: 1.18 / 0.56 GW
Energy: 11.1 TWh/yr

Weighted cost: **7.3 $-ct/kWh**

Curtailment of excess wind/ PV energy → could supply a Power-to-Liquid plant, which is highly flexible



Annual: 70% share of renewables
(of useful energy)

Technology: PV / wind / gas
Size: 1.5 / 2.0 / 1.61 GW
Energy (useful): 11.1 TWh/yr
Energy (total): 3.6 / 5.3 / 3.2 TWh/yr = 12.1 TWh/yr

Weighted cost: **6.8 ~~7.3~~ $-ct/kWh**
(7.3 $-ct/kWh goes down to 6.8 $-ct/kWh, even if only 4.2 $-ct/kWh value is given to excess energy)

Thank you!