VPPs and embedded PV

Presentation at the
Global Renewable Energy Support Programme

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Agenda

Virtual Power Plants

Embedded PV

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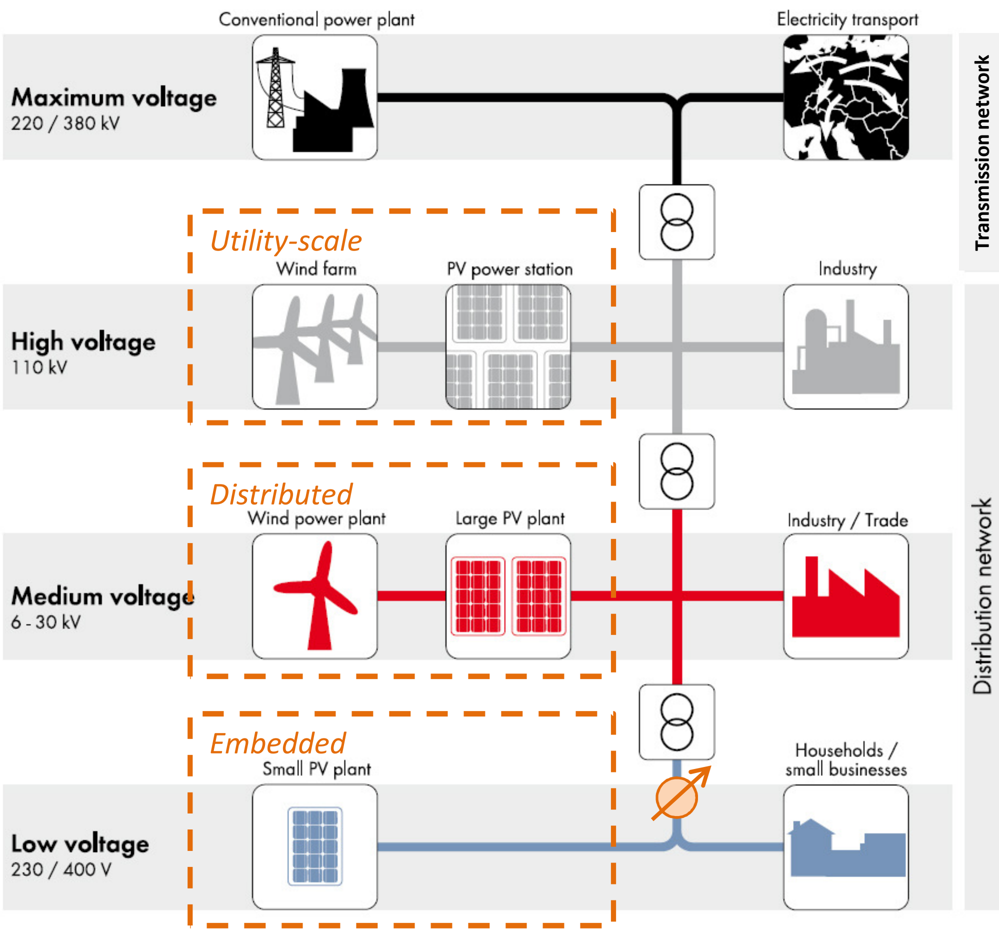
What is embedded PV?



1. 75…100 MW and more
2. < 1…30 MW
3. 1…1,000 kW

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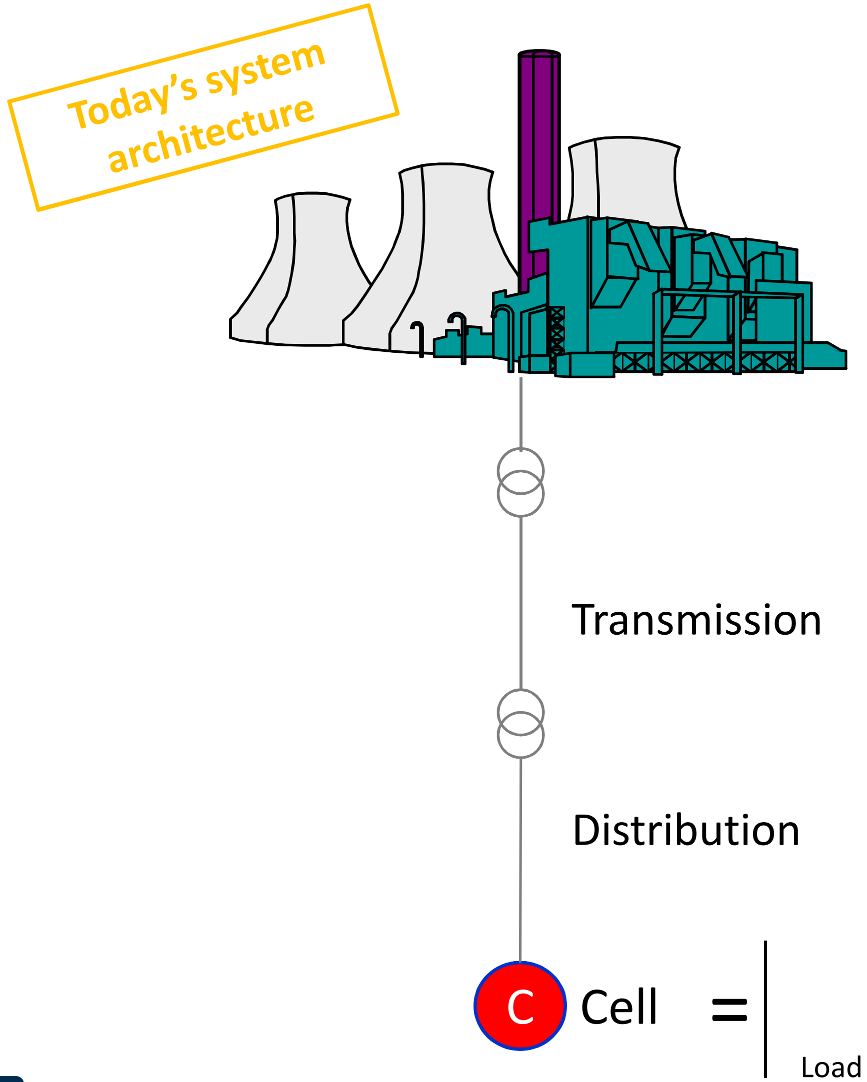
Sources: SMA; CSIR analysis

Renewables projects have inherently very different sizes – but currently only large projects are incentivised through REIPPPP

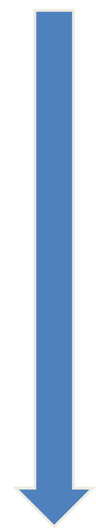
	1 Large: Utility-scale	2 Medium: Distributed Generators	3 Small: Embedded Generators
PV	 75 MW	  1…30 MW	 1…1,000 kW
Wind	 > 100 MW	 1…30 MW	 *Farmers* 0.5…2 MW
CSP	 100 MW	*Projects too small for technology*	*Embedded projects too small for technology*
Biomass / Landfill Gas	  >10 MW	*Possible, but technology generally leads to larger projects*	*Embedded projects too small for technology*
Biogas	*Feedstock logistics prohibitive for large projects*	 *Municipalities (@ waste water treatment)* 0.5…2 MW	 *Farmers* 0.5…2 MW
Small Hydro	*Projects typically not utility-scale*	 0.5…2 MW	*Embedded projects too small for technology*

Sources: CSIR analysis

In today's power system, "cells" are simply consumers (load) – generation and balancing of supply/demand happens centrally



Balancing of supply/demand on central system level



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

Sources: CSIR analysis

Where a “cell” today is simply a consumer (load), in future it will consist of generation, storage and manageable loads

A cell can be:

- A residential complex
- A commercial complex
- Individual buildings on CSIR’s campus
- A whole village
- An industrial customer
- Etc.

C Cell = Generation | Storage | Load

Generation options can be:

- PV
- Wind
- micro CHP (mCHP), fuel cells
- Biogas

Storage options can be:

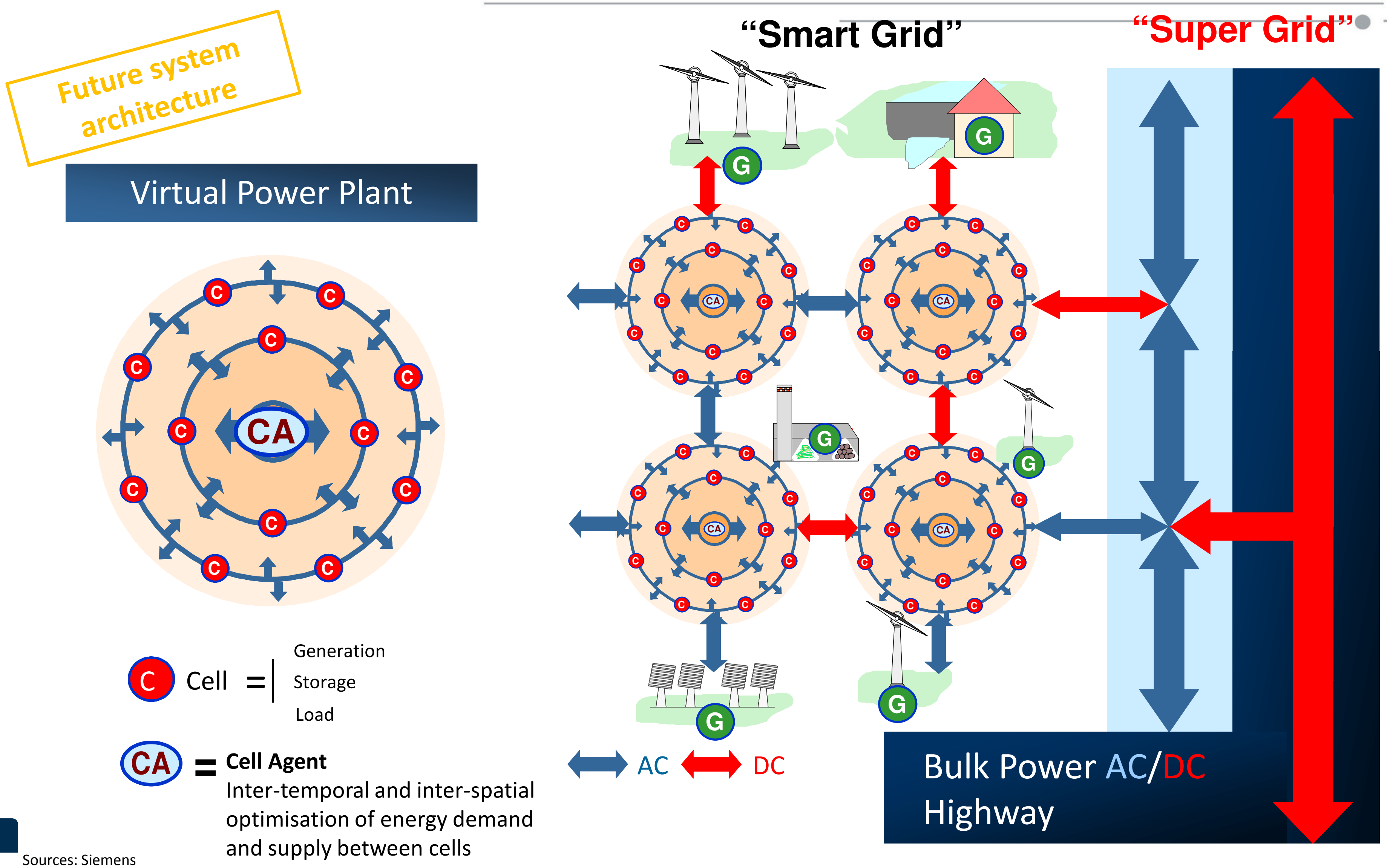
- Batteries
- Thermal storage for space heating
- Thermal storage for industrial process heat
- Power-to-gas / power-to-H2

Load options can be:

- Non-interruptable / non-manageable loads
- Manageable loads (e.g. fridges, space cooling, space heating, pool pumps, water heating, etc.)
- Fuel switch (e.g. power-to-gas or power-to-fuel)

Sources: CSIR analysis

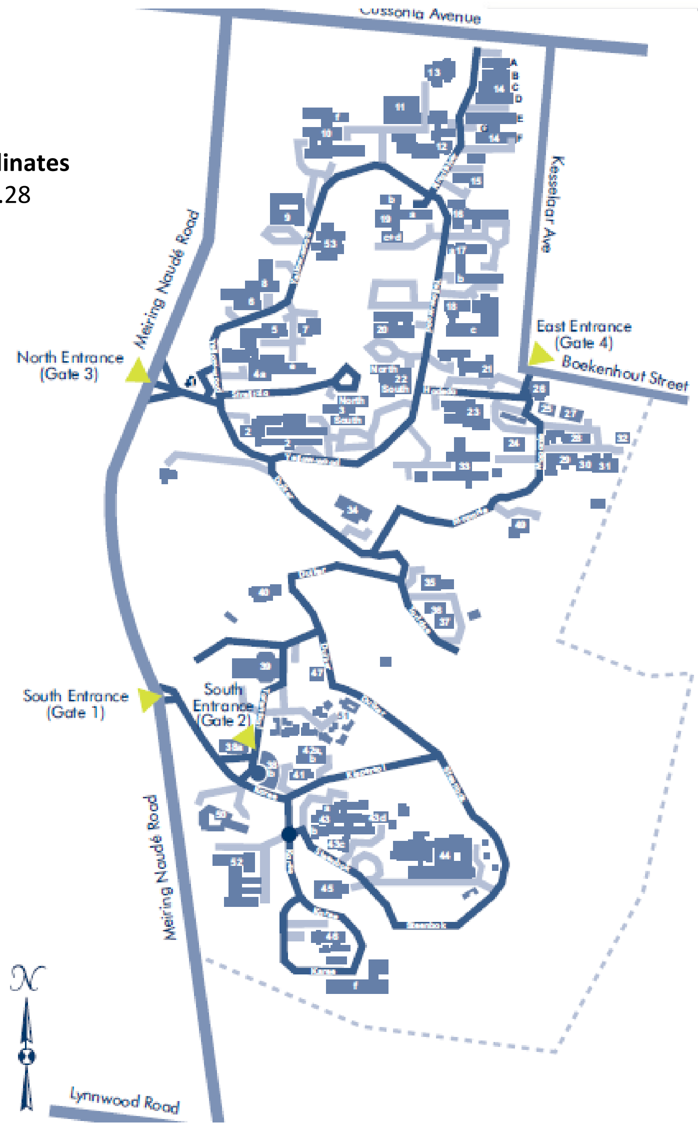
Future power-system architecture: multiple cells of generation, storage and load are balanced by cell agents and form a Virtual Power Plant



Sources: Siemens

Today: CSIR's main campus in Pretoria is a large electricity consumer

GPS coordinates
-25.75, 28.28

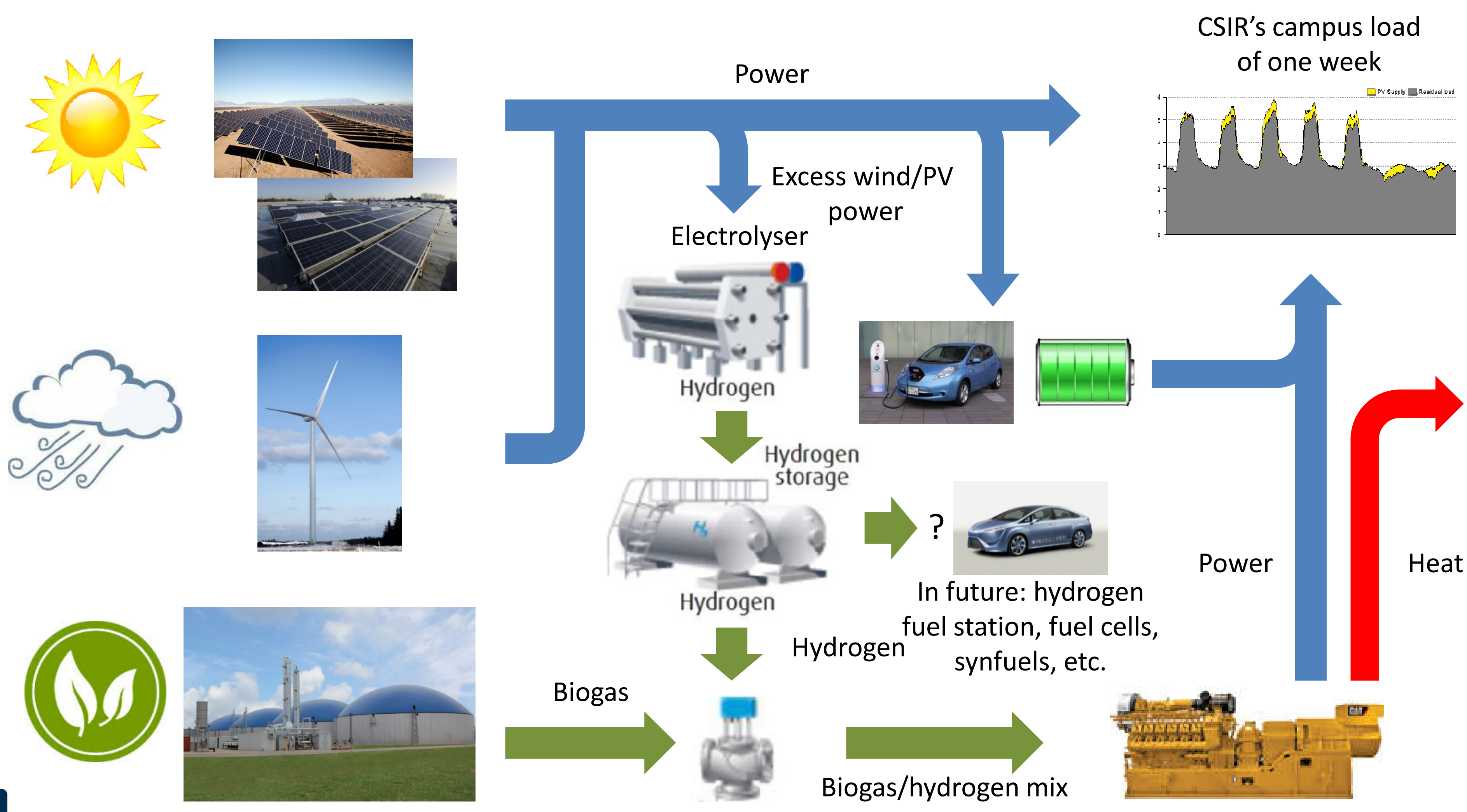


CSIR Campus today

- *52 buildings*
- *150 ha*
- *30 GWh/yr electricity demand*
- *3 MW base load*
- *5-6 MW peak load*

Sources: CSIR analysis

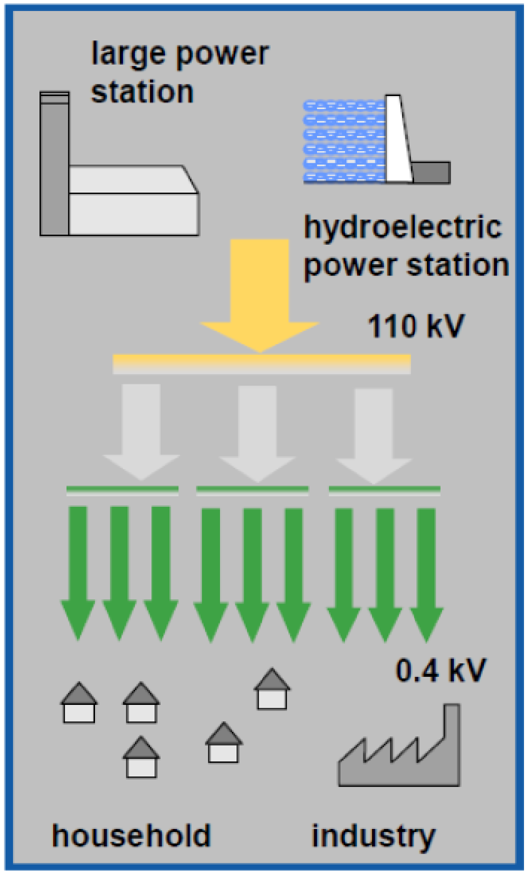
Vision:
The three primary energy sources sun, wind & biomass are at the core



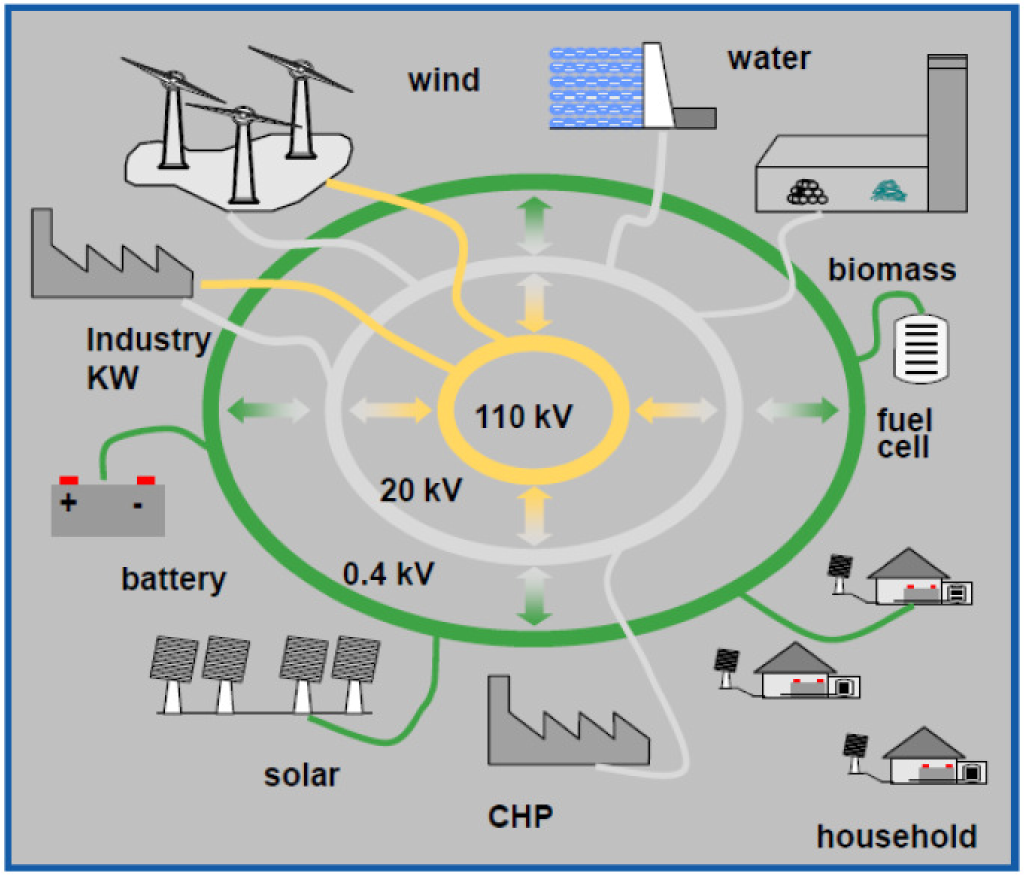
Sources: Enertrag; modified and expanded by CSIR

The future power system is more distributed and more flexible

Today: Supply follows Load



Tomorrow: Load follows Supply



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What is different with a high share of renewables?

Distributed Power Generation	Renewables are inherently smaller in size than conventionals and they are modular	**Grid-technology Implications**
System Planner's / Operator's Paradigm Shift	Paradigm shift from: "supply follows load" to "dispatchable load and dispatchable supply follow fluctuating supply"	**Energy Planning and Operational Implications**
Democratisation of Power Generation	Renewables attract new funders due to granularity and fixed-deposit type of investment → ownership base very different as compared to conventionals	**Socio-economic Implications**

Background: PV and wind are intermittent (not "schedulable" / dispatchable) and have zero marginal costs → therefore "must run" in any market setting

Sources: CSIR analysis

Advantages of incentivising embedded PV

Job creation & local content

- Potential for rural enterprises to run a **"micro-utility business"** with small-scale PV generators → wherever there is a grid, there is a PV business opportunity!
- Huge potential for **SMMEs** in PV **design, installation & verification** for residential & commercial customers

Reduced grid losses and system costs

- Embedded PV is close to the load, i.e. **grid losses are low** (saves add. up to 5% of costs)
- Generally only very little grid strengthening and no grid extension required (**PV follows the grid**)
- Aggregated supply profile of spatially distributed embedded PV generators is very smooth and highly predictable

Reduced transaction costs

- Project development costs, legal fees, environmental assessment, etc. are all reduced or non existent for embedded PV as compared to large PV installations

Funding easier due to granularity (small project size, R 100,000 to few millions)

- With a proper standard offer defined, rooftop PV installation would become bankable
- Banks could put the asset into the home loan for easy financing

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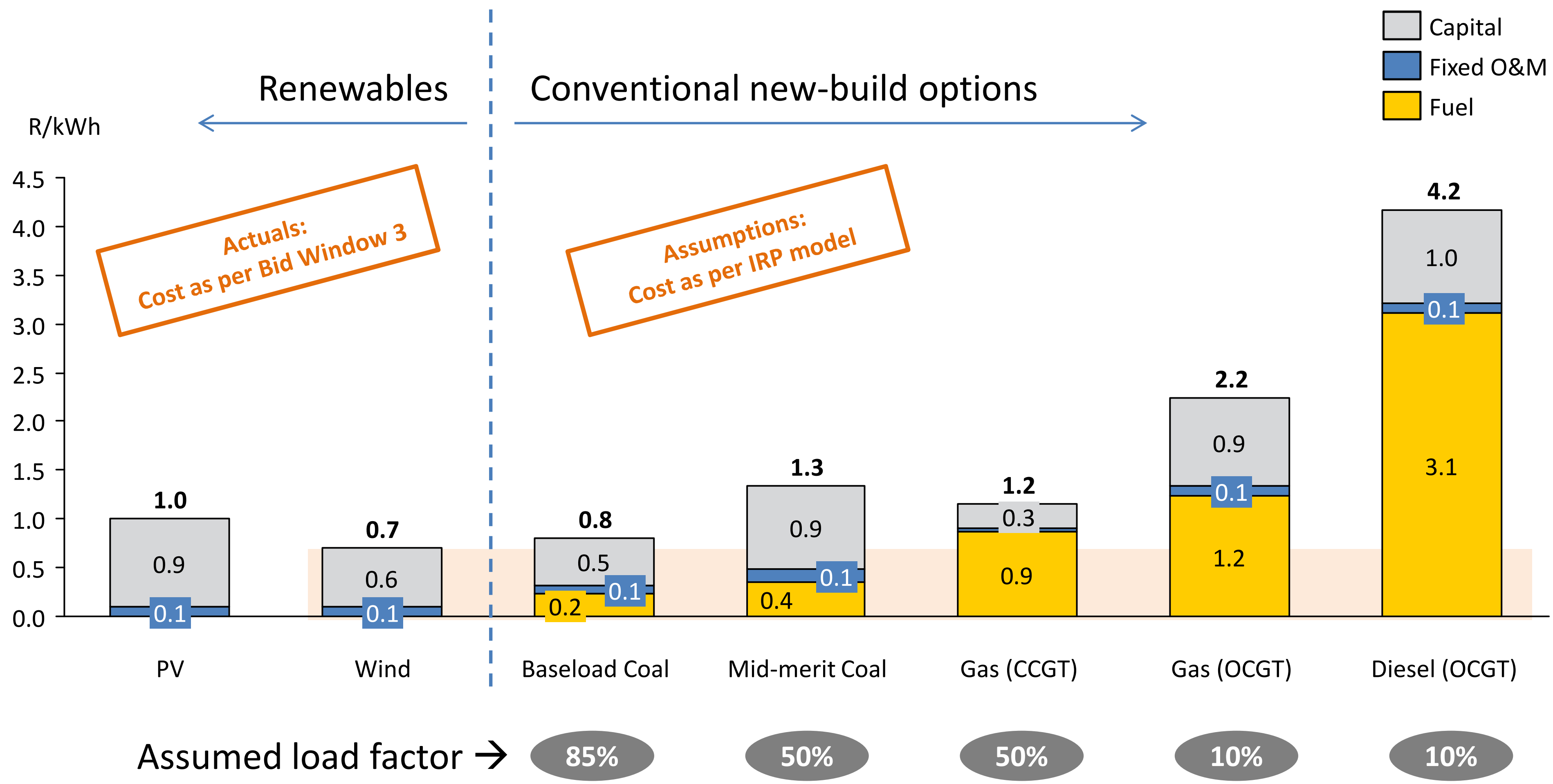
Source: Eskom EPMD analysis

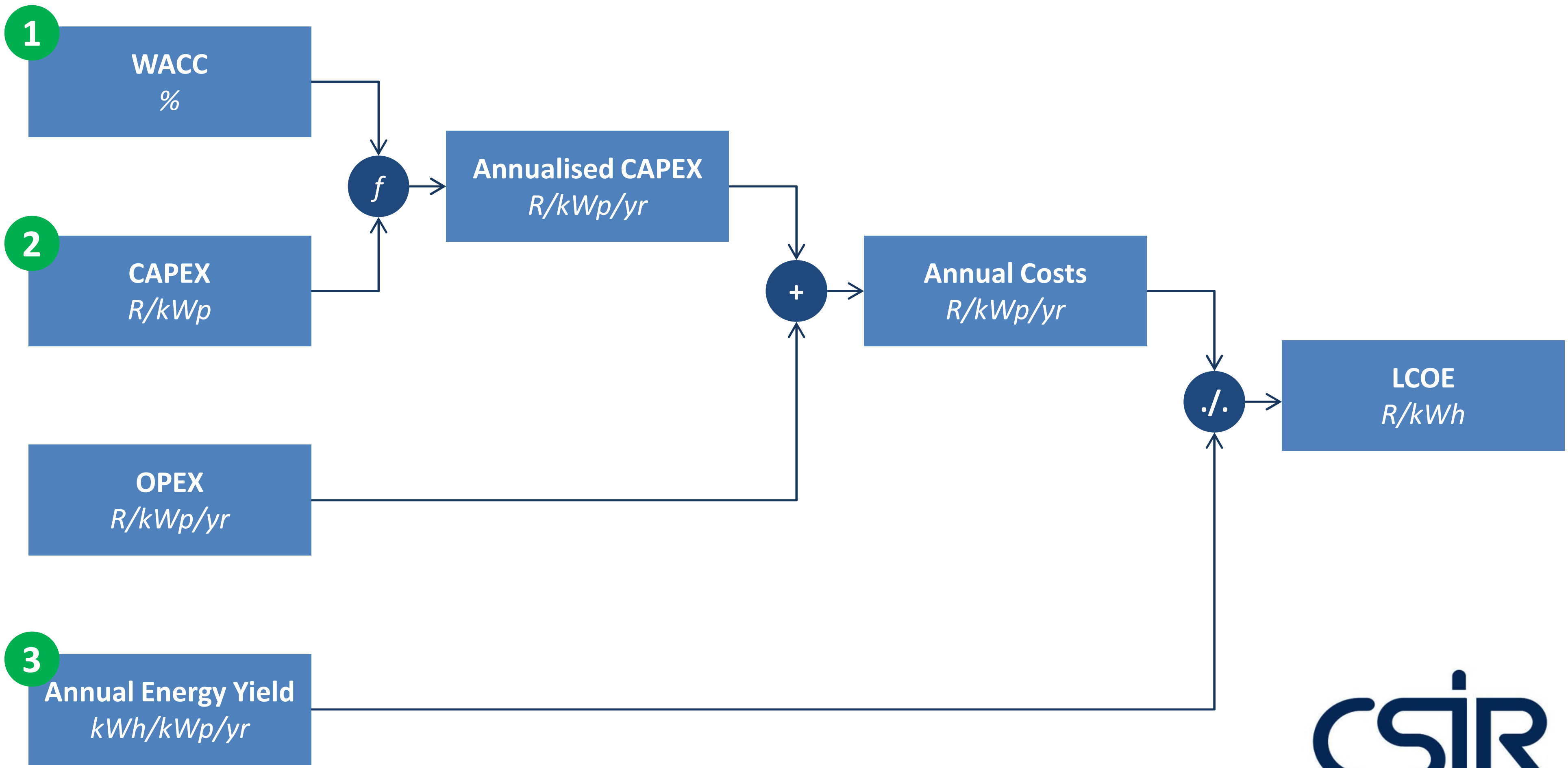
PV and wind are cost-efficient fuel-savers for gas power plants today



Assumption: Typical full-load hours per generator assumed (92% for nuclear, 85% for coal, 50% for CCGT, 10% for OCGT). 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); average efficiency for CCGT = 50%, average efficiency for OCGT = 35%; gas @ R120/GJ

Source: IRP Update; REIPPPP outcomes; CSIR analysis

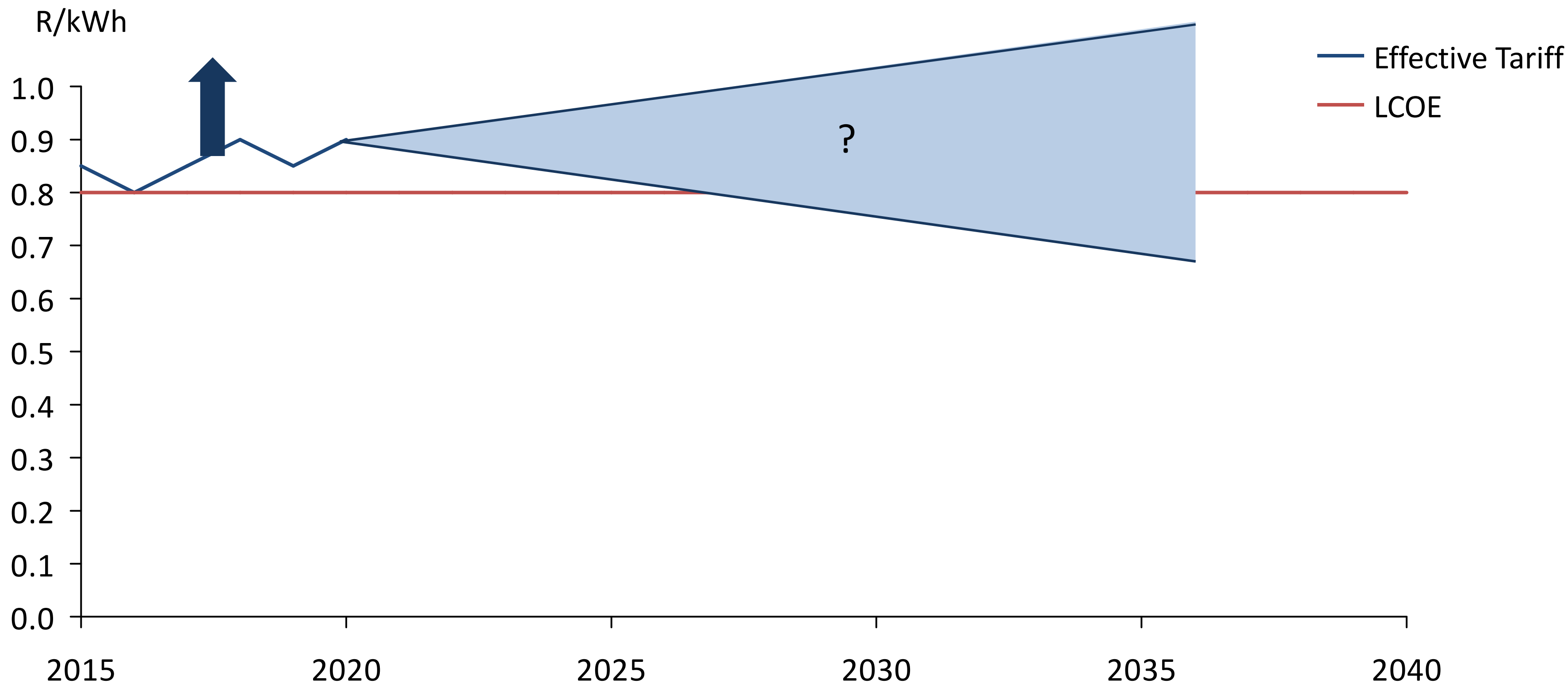
PV has three main cost drivers – LCOE locked in over lifetime of asset



Note: Without inflation, i.e. In real terms; LCOE = Levelised Cost of Energy = discounted total lifetime cost of the PV installation divided by discounted total lifetime energy yield of PV installation

Sources: CSIR analysis

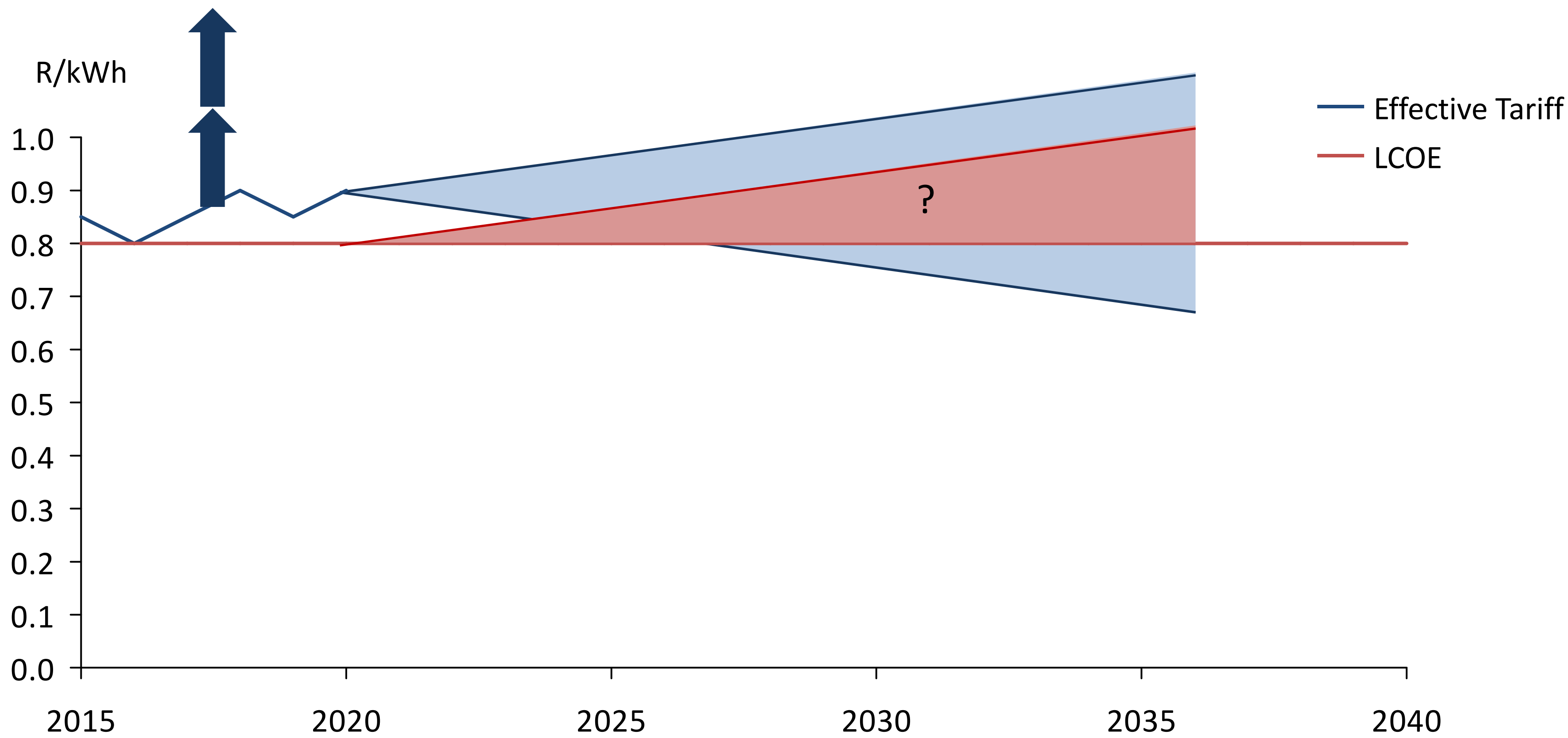
Uncertainty about future tariff makes investor require higher initial tariff – with potential subsequent windfall profits



PV investment similar to fixed-deposit savings account, thus requires the same investment certainty, to bring costs down

Note: Without inflation, i.e. In real terms; LCOE = Levelised Cost of Energy = discounted total lifetime cost of the PV installation divided by discounted total lifetime energy yield of PV installation
Sources: CSIR analysis

Uncertainty about future offtake increases LCOE, which pushes required initial tariff additionally up – with subsequent windfall profits



PV investment requires security about tariff and about offtake in order to bring total cost to the power system down

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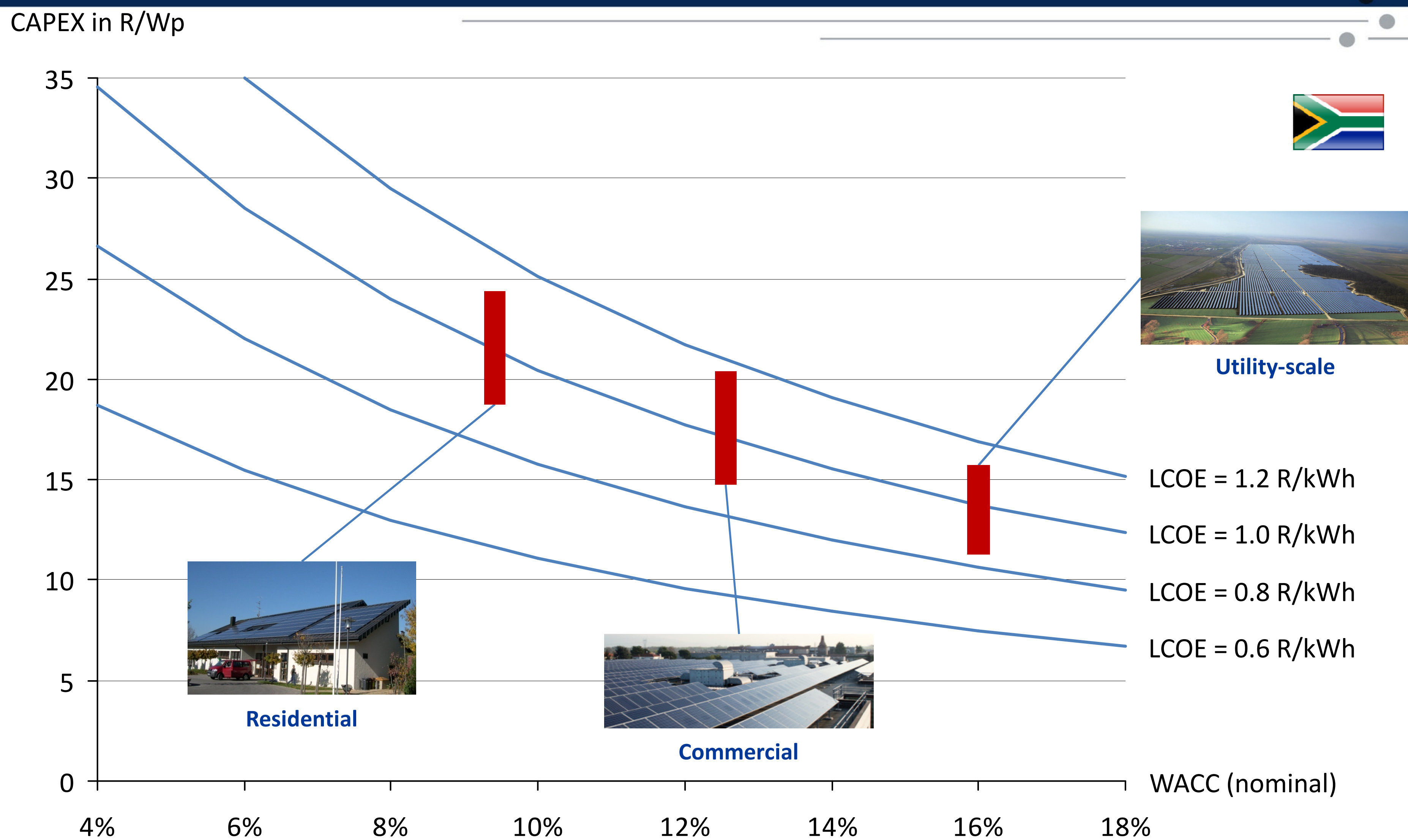
Note: Without inflation, i.e. In real terms; LCOE = Levelised Cost of Energy = discounted total lifetime cost of the PV installation divided by discounted total lifetime energy yield of PV installation
Sources: CSIR analysis

Higher CAPEX of residential or commercial PV can be compensated by lower cost of capital



Assumptions: 20 years lifetime, 1,700 kWh/kWp/yr specific energy yield in year 1, 0.8% annual degradation, 200 R/kWp/yr OPEX, 6% inflation

Source: CSIR analysis

Thank you!

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