Decentralised Energy Solutions
The CSIR Energy Autonomous Campus

Presentation at POWER-GEN & DistribuTECH Africa 2017

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The CSIR is South Africa's multidisciplinary research council

- The CSIR's Executive Authority is the South African Minister of Science and Technology

In numbers:

72yrs 1945 - 2017	**2 668** Total staff	**350** SET base with PhD
490 Publication equivalents	**~ $200 m** Total operating income	**1 980** Total in SET base

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Based on 2015/16 forecast

Agenda

Global Context

Implications for Africa

Case Study: Microgrid Design in South Africa

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What is different today as compared to just a few years ago?

Renewables are now cost competitive to alternative new-build options in large parts of Africa

- Renewables became cost competitive to conventionals during the last decade (PV: last 2-3 years)
- Subsidy-driven market creation in first-mover renewables regions (US, Europe, Japan) led to technology improvements and mass manufacturing

In matured markets, renewables are a substitution in a volume-wise stagnating energy system

- Renewables compete with an existing, steady-state energy system → fuel savers for the existing fleet
- Major incumbents with business models based on "large, central" suffer in terms of market share

In emerging markets, this is different: renewables can be at the core of the energy-system expansion

- Renewables compete with alternative new-built options / future scenarios for the energy structure
- More than just fuel savers, they change the entire paradigm on which energy systems were traditionally planned, designed, built and operated (large, central → small, distributed)

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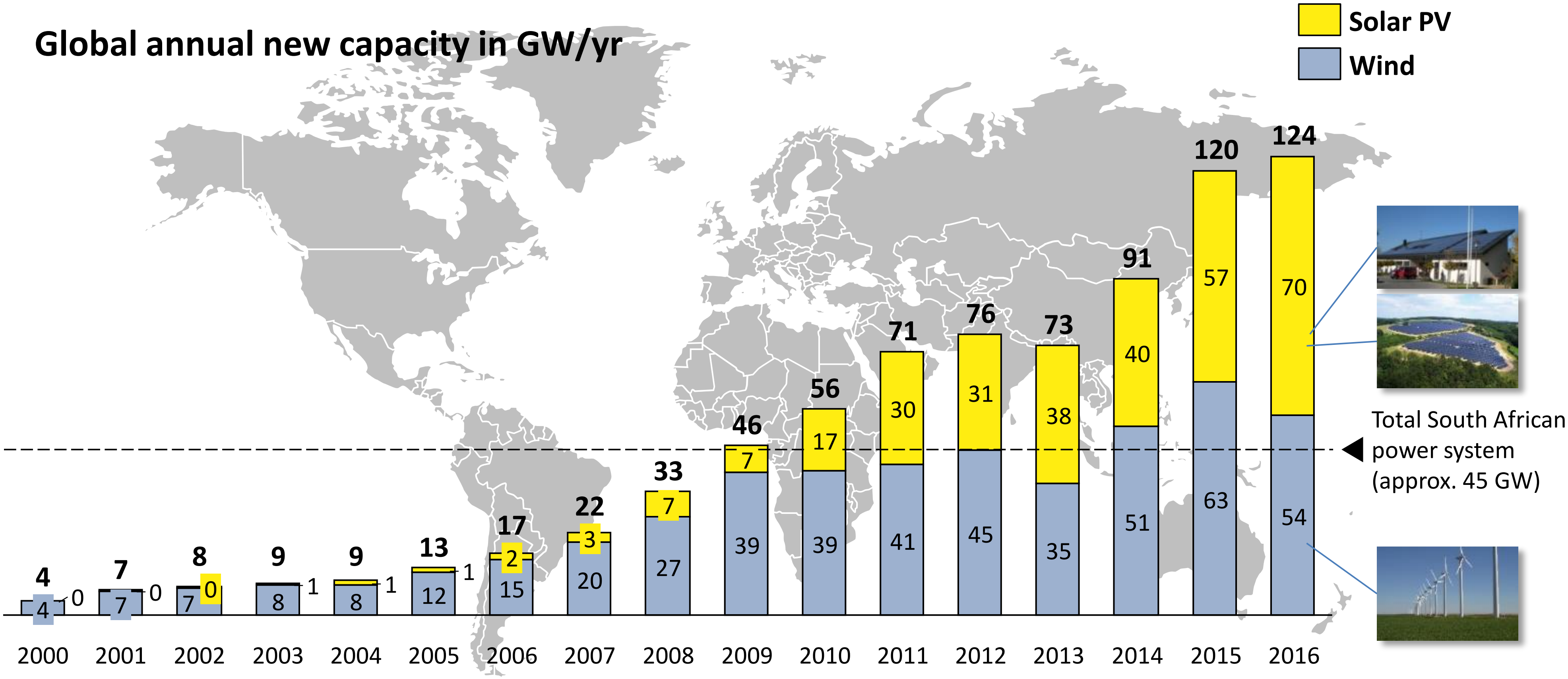
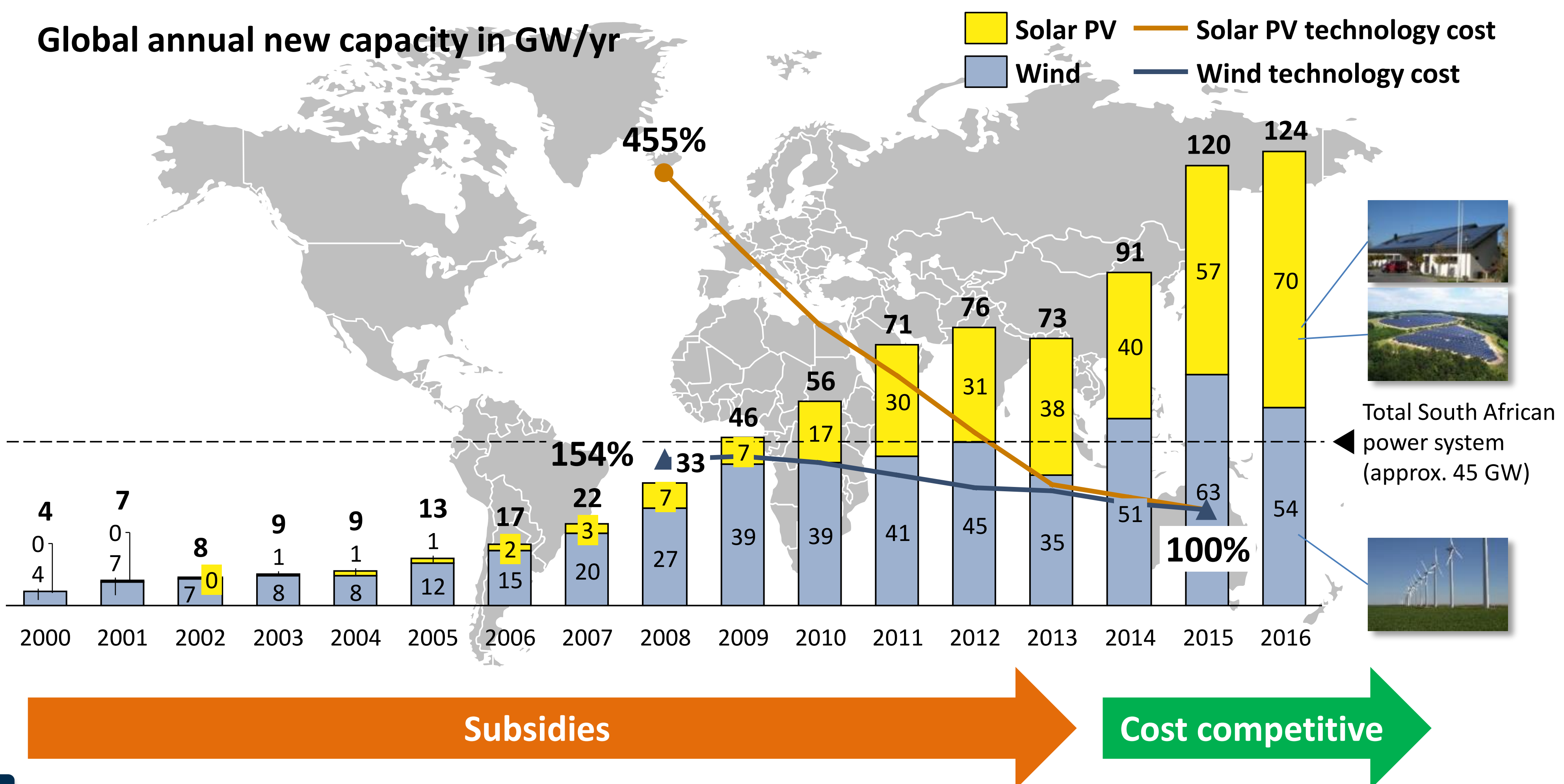
World:
In 2016, 124 GW of new wind and solar PV capacity installed globally



This is all very new: Roughly 80% of the globally existing solar PV capacity was installed during the last five years

Sources: GWEC; EPIA; BNEF; CSIR analysis

World:
Significant cost reductions materialised in the last 5-8 years

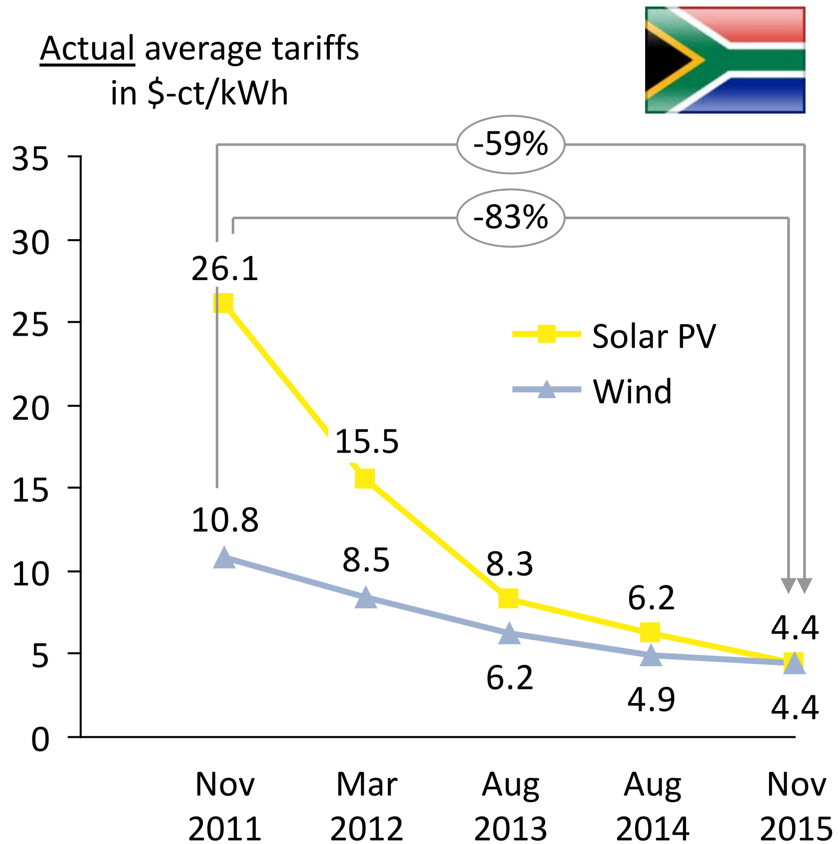


Sources: IEA; GWEC; EPIA; BNEF; CSIR analysis

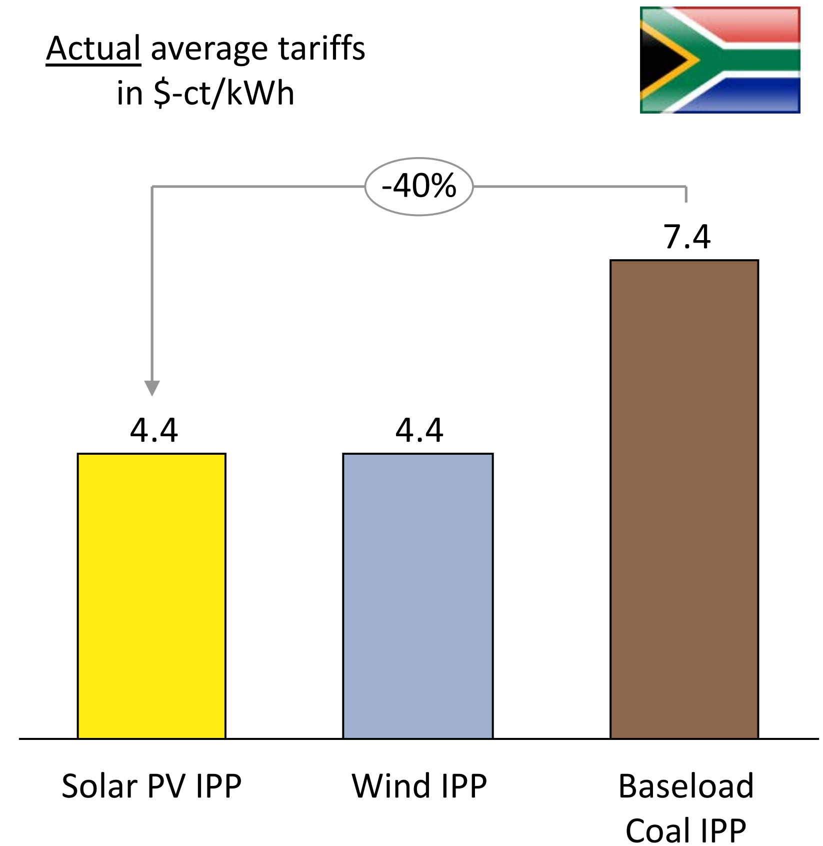
Actual tariffs: new wind/solar PV 40% cheaper than new coal in RSA

Results of Department of Energy's RE IPP Procurement Programme (REIPPPP) and Coal IPP Proc. Programme

Significant reductions in actual tariffs ...



... have made new solar PV & wind power 40% cheaper than new coal in South Africa today



Notes: Exchange rate of 14 USD/ZAR assumed   Sources: http://www.energy.gov.za/files/renewable-energy-status-report/Market-Overview-and-Current-Levels-of-Renewable-Energy-Deployment-NERSA.pdf; http://www.saippa.org.za/Portals/24/Documents/2016/Coal%20IPP%20factsheet.pdf; http://www.ee.co.za/wp-content/uploads/2016/10/New_Power_Generators_RSA-CSIR-14Oct2016.pdf; StatsSA on CPI; CSIR analysis

What is different with a high share of renewables?

Distributed	Renewables are distributed in nature	**Grid Planning**
Variable	Solar and wind are variable (weather dependent) with zero marginal cost	**Complemented by Flexibility**
Granular	Renewables projects are orders of magnitude smaller than conventional and have much shorter lead times	**Parallelisation of Implementation, Speed Adjustable**

Sources: CSIR analysis

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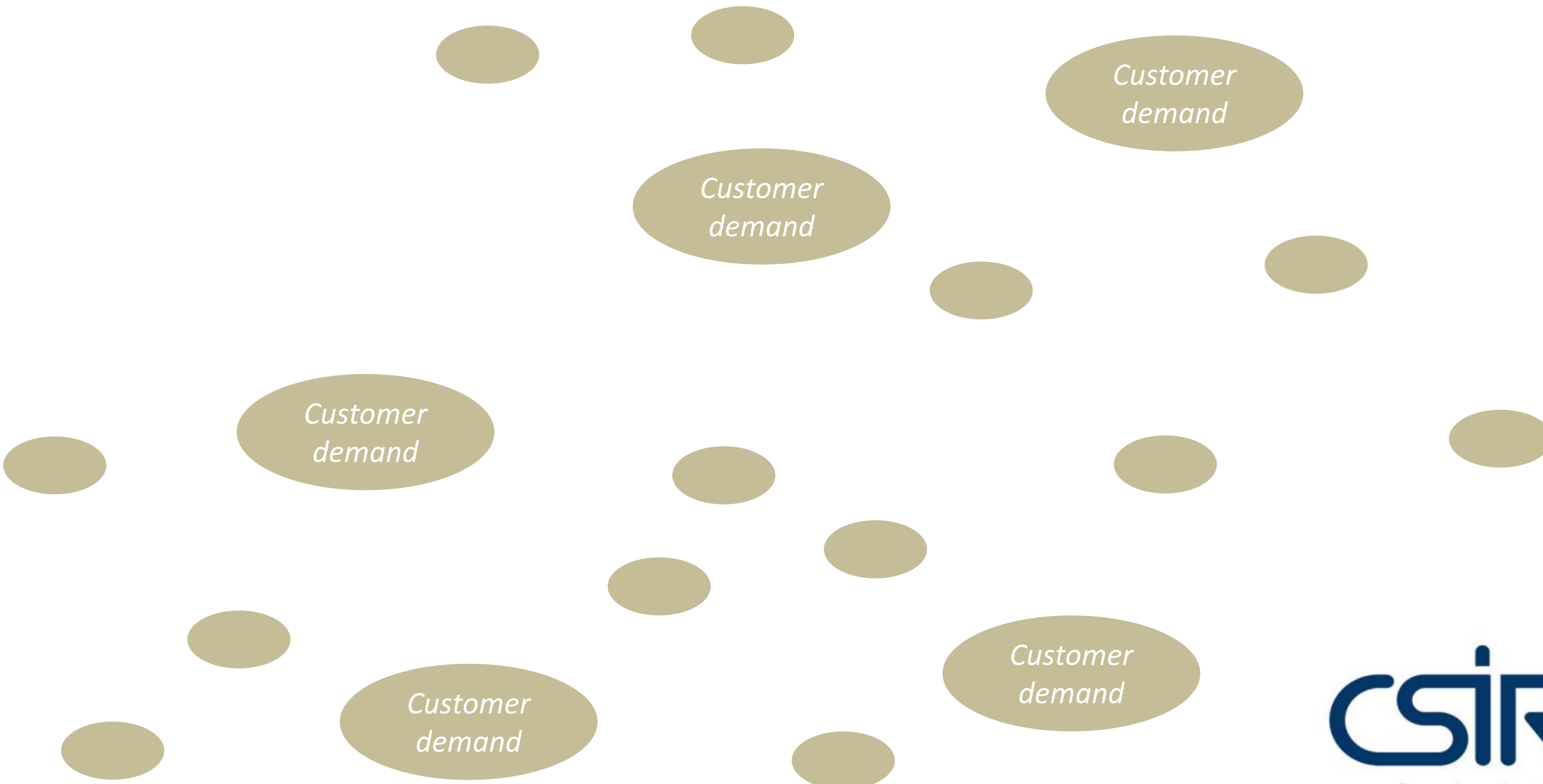
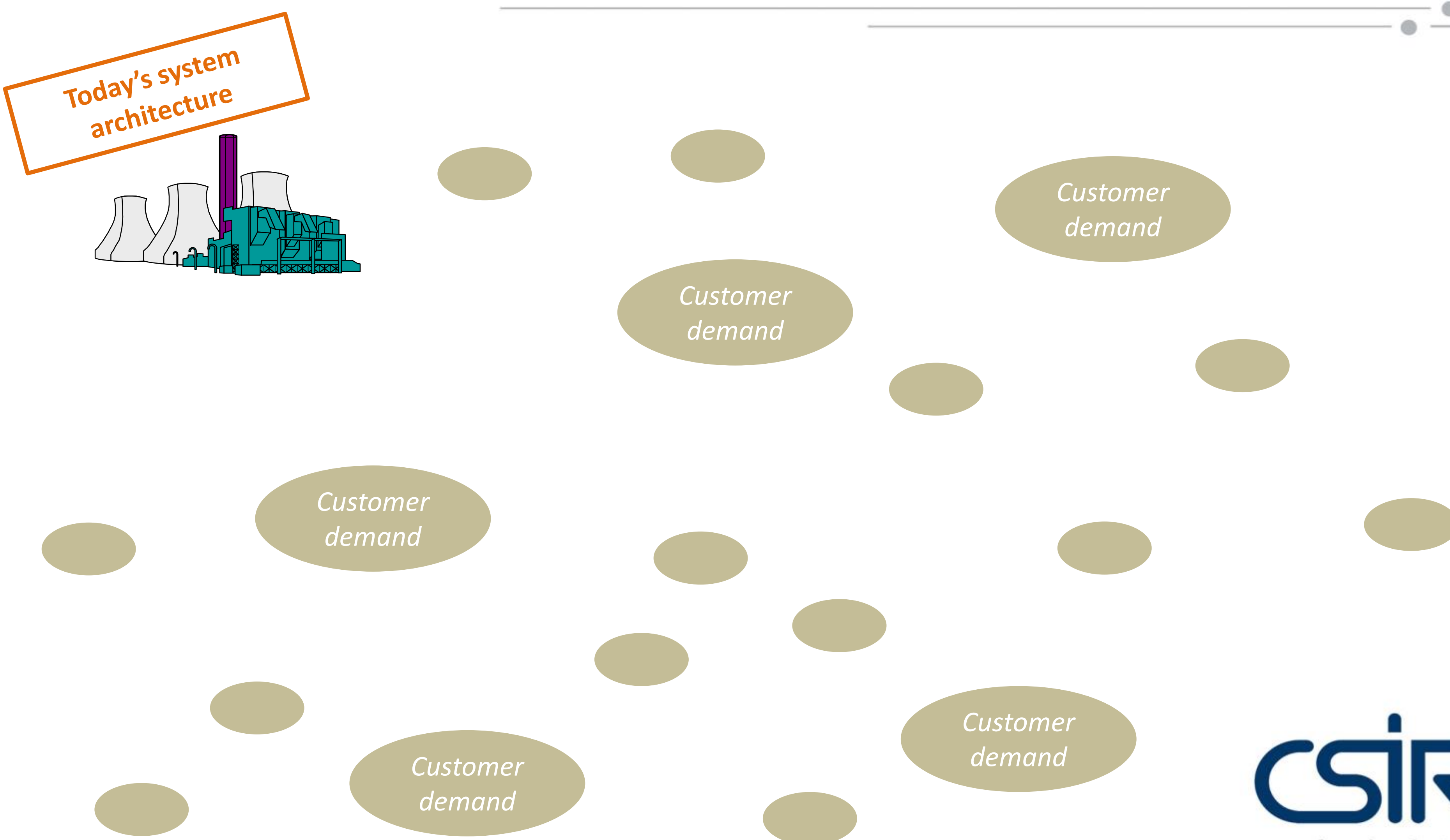
Customer demand is always scattered across more or less wide areas



Historically, this demand was supplied by large, central power generators with a high-voltage backbone and an ever finer-getting grid



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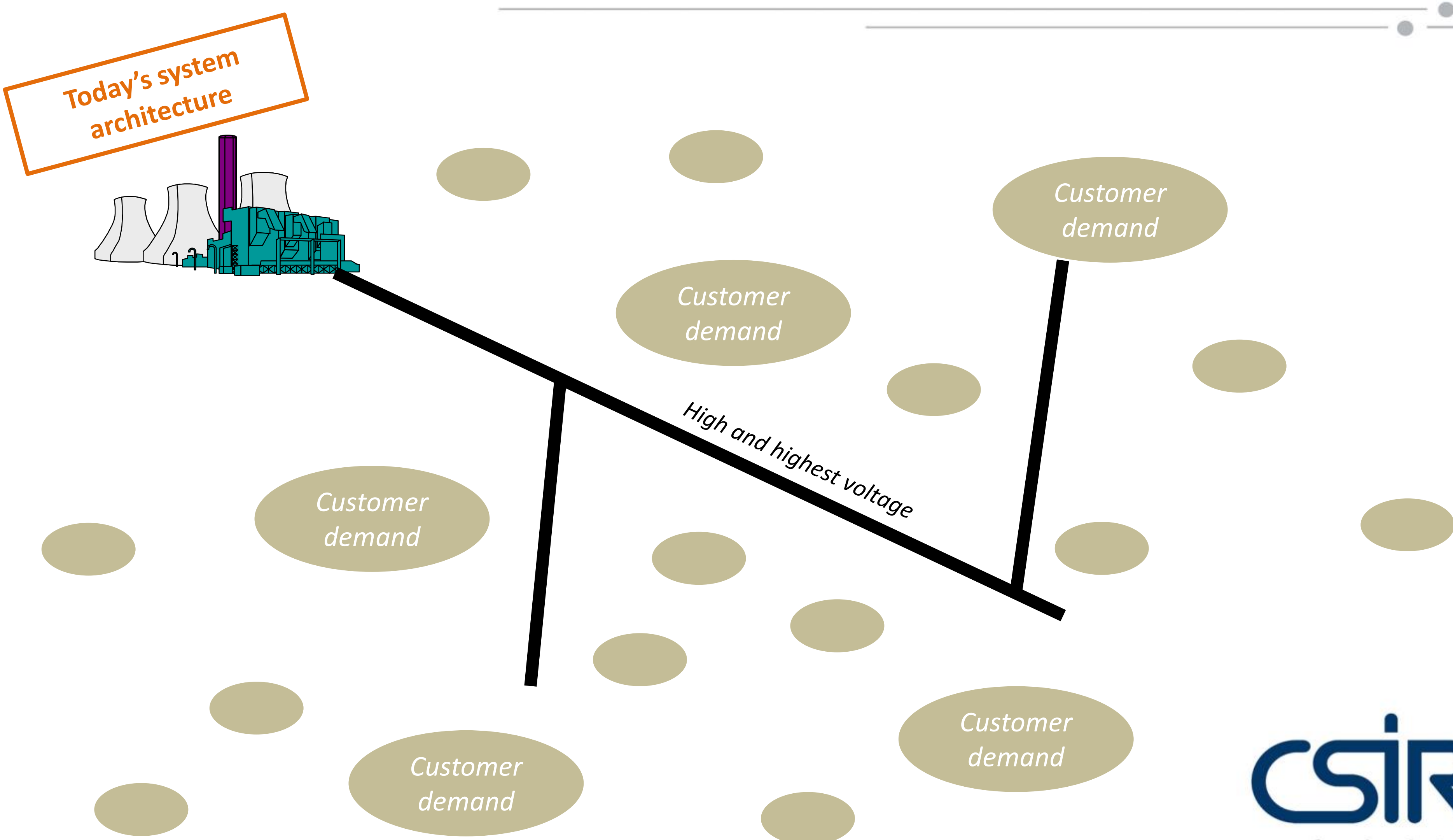

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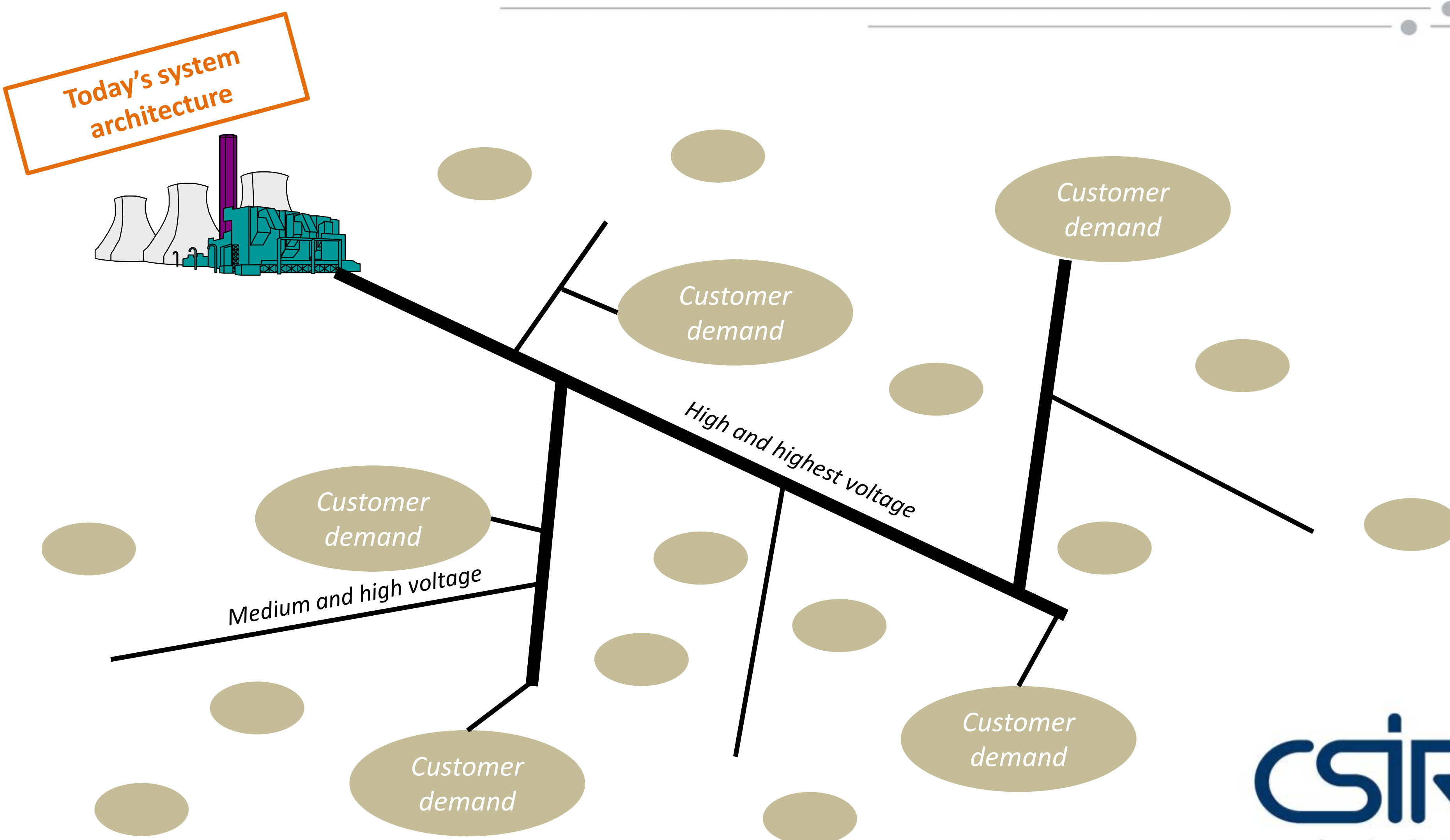

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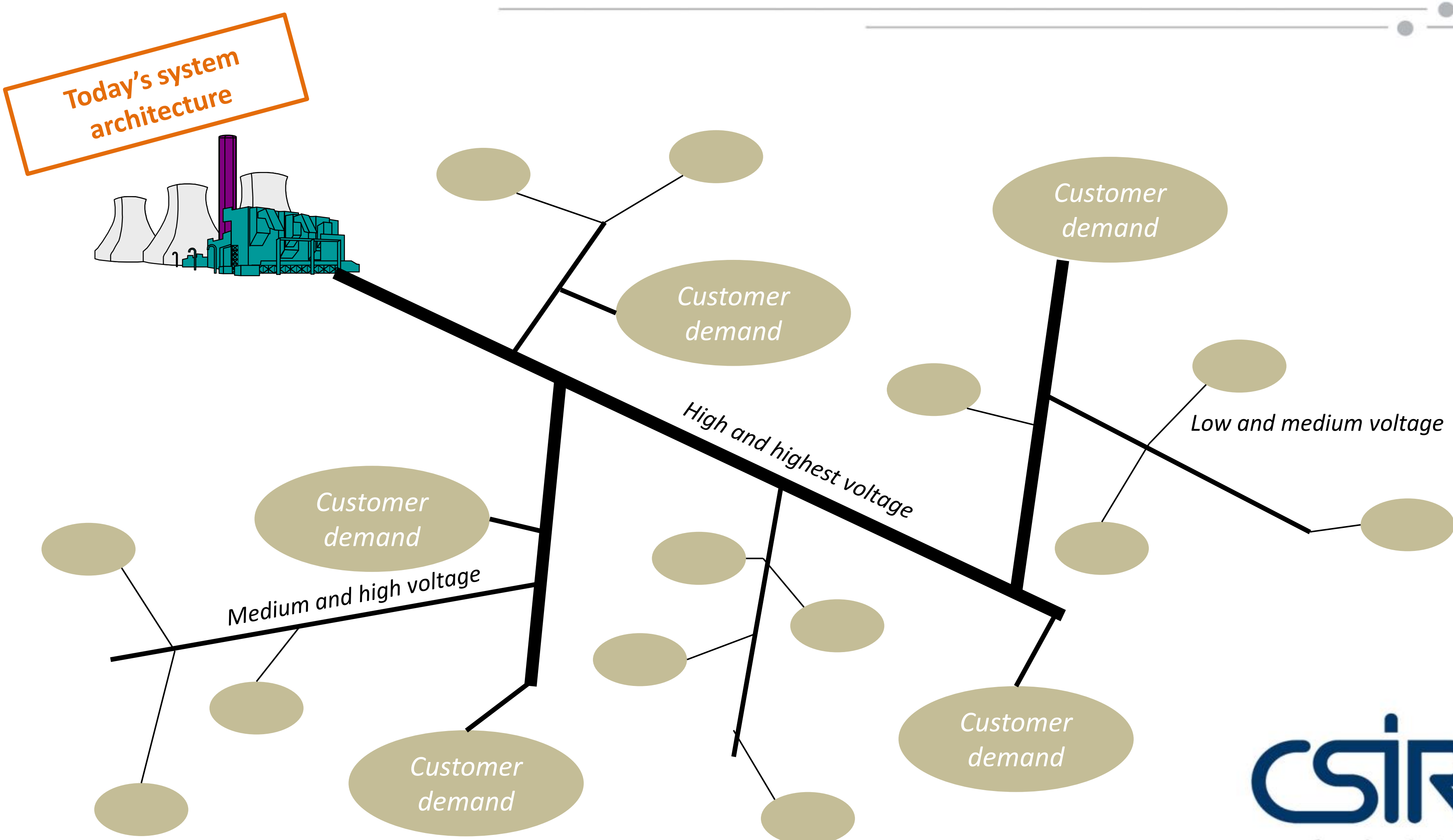
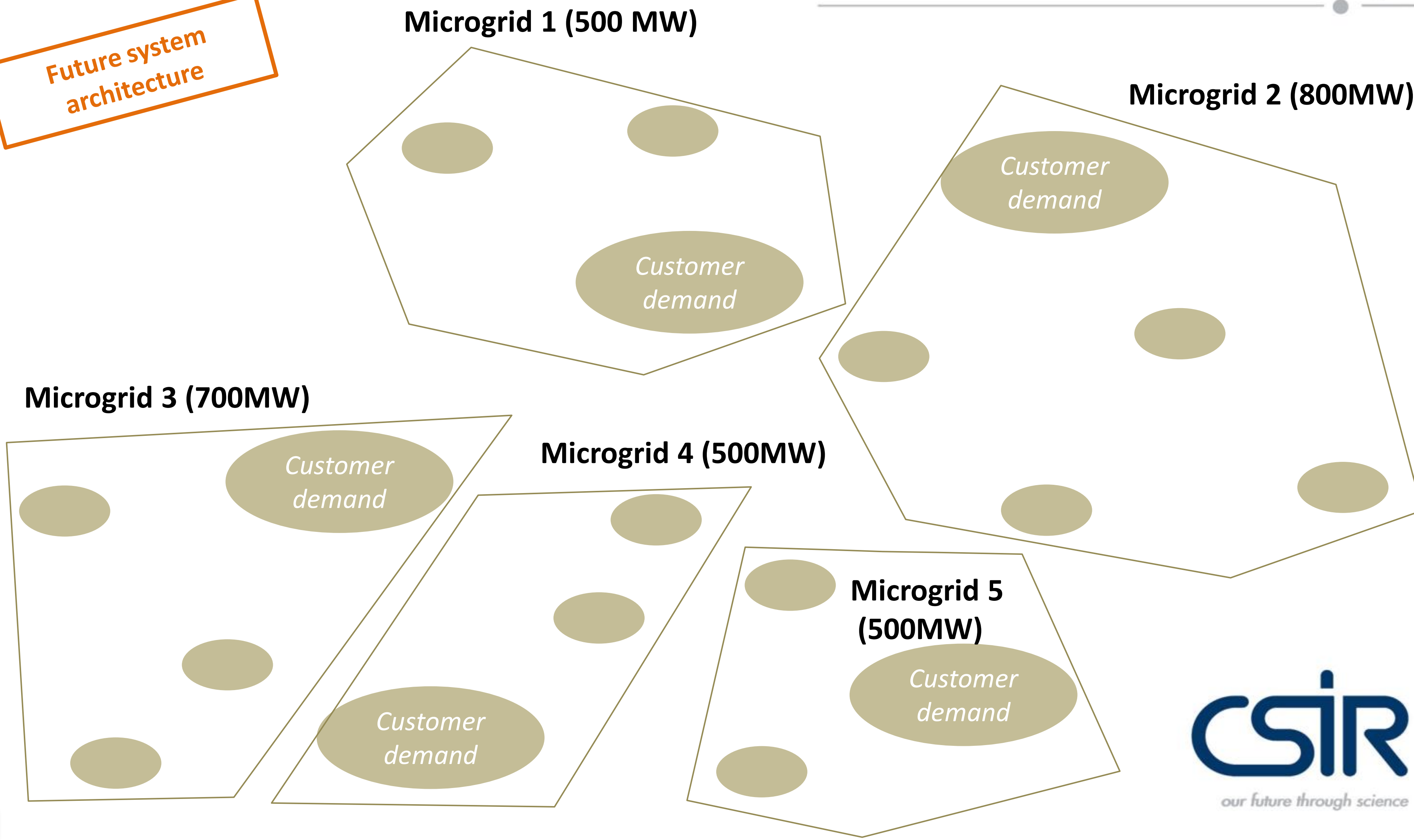


In future, because of cost-competitiveness of distributed renewables, the system architecture can be based on interconnected microgrids

Future system architecture



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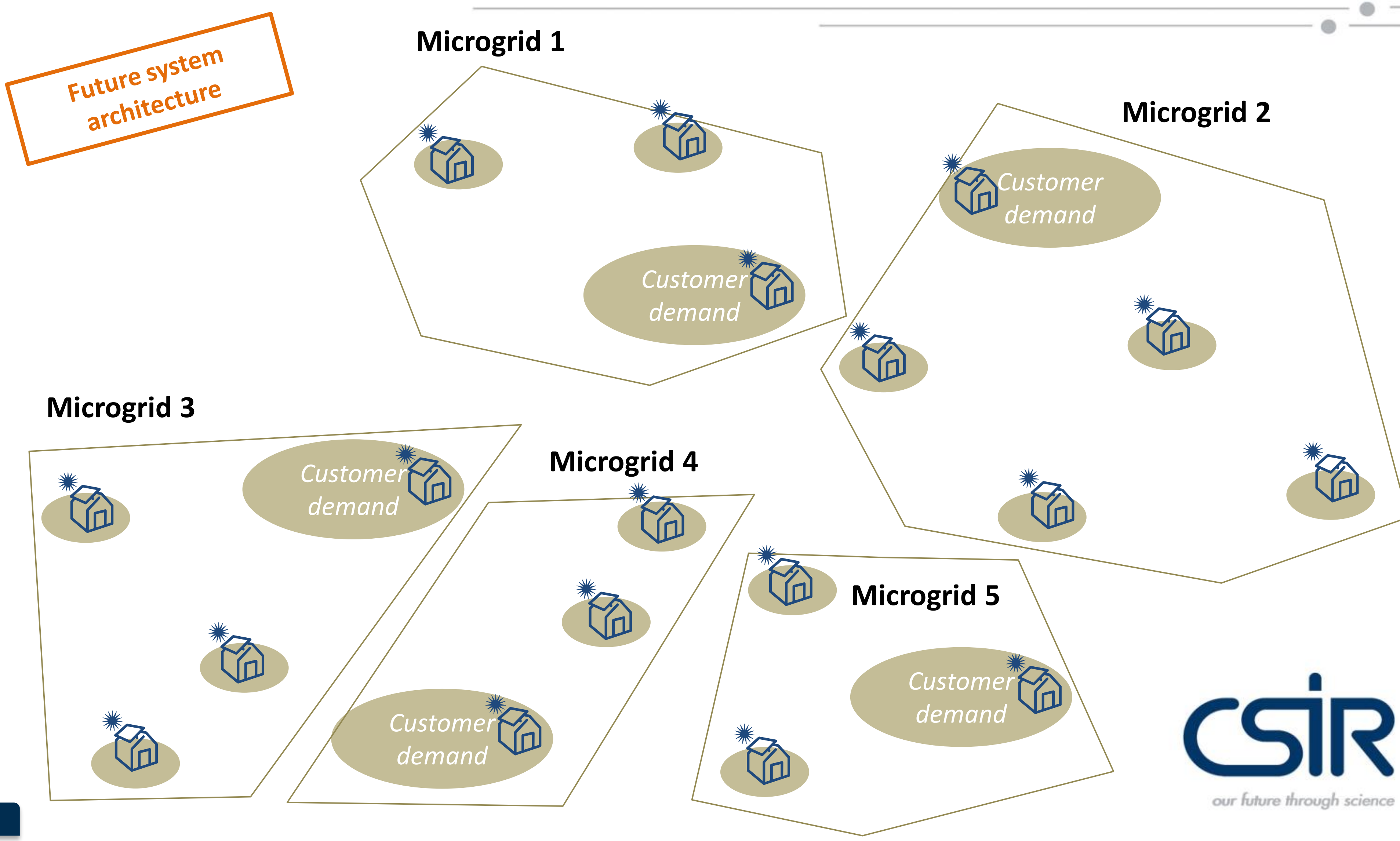
Solar PV (roof & ground-mounted) will be installed literally everywhere



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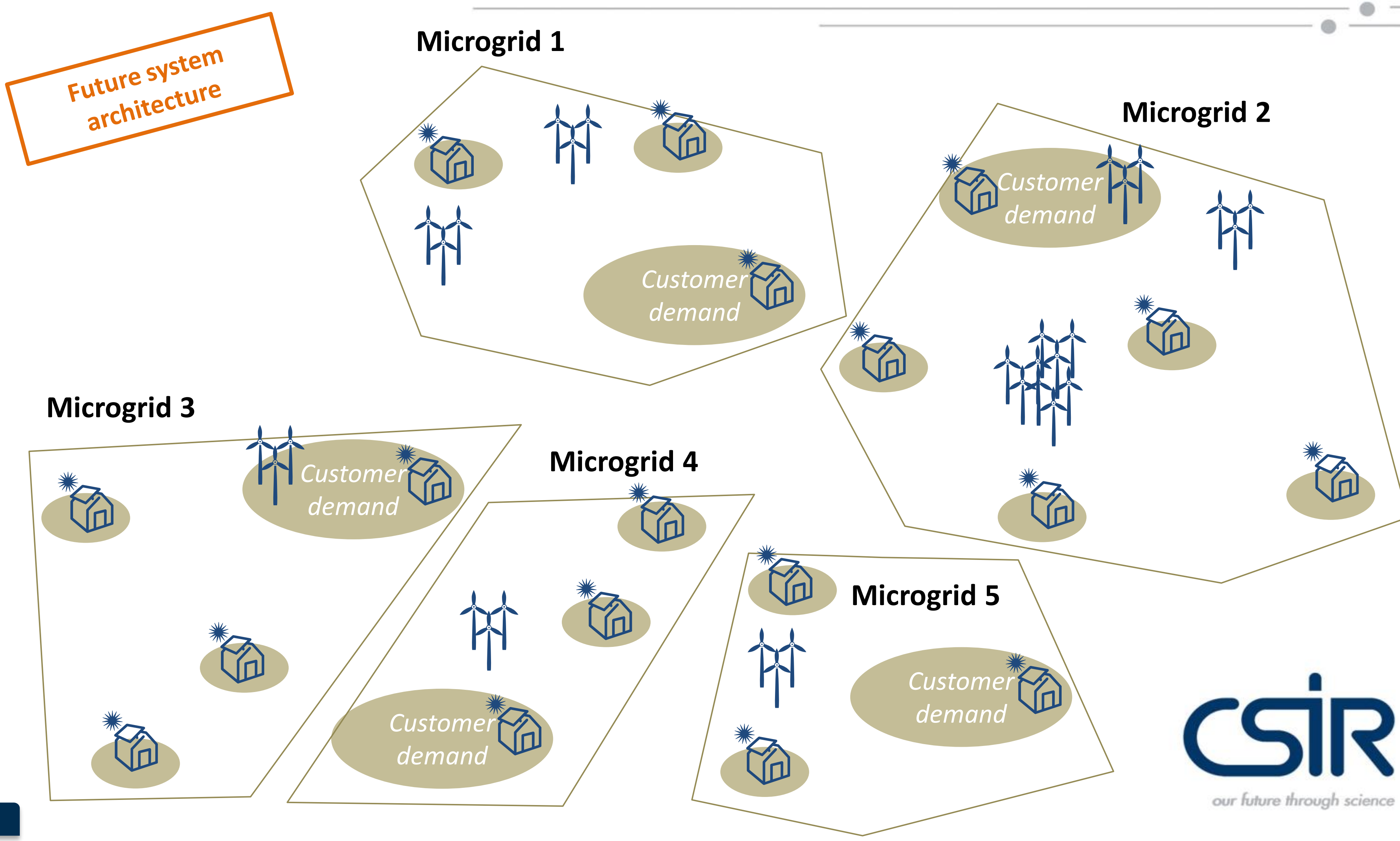
Wind turbines will complement where economically viable



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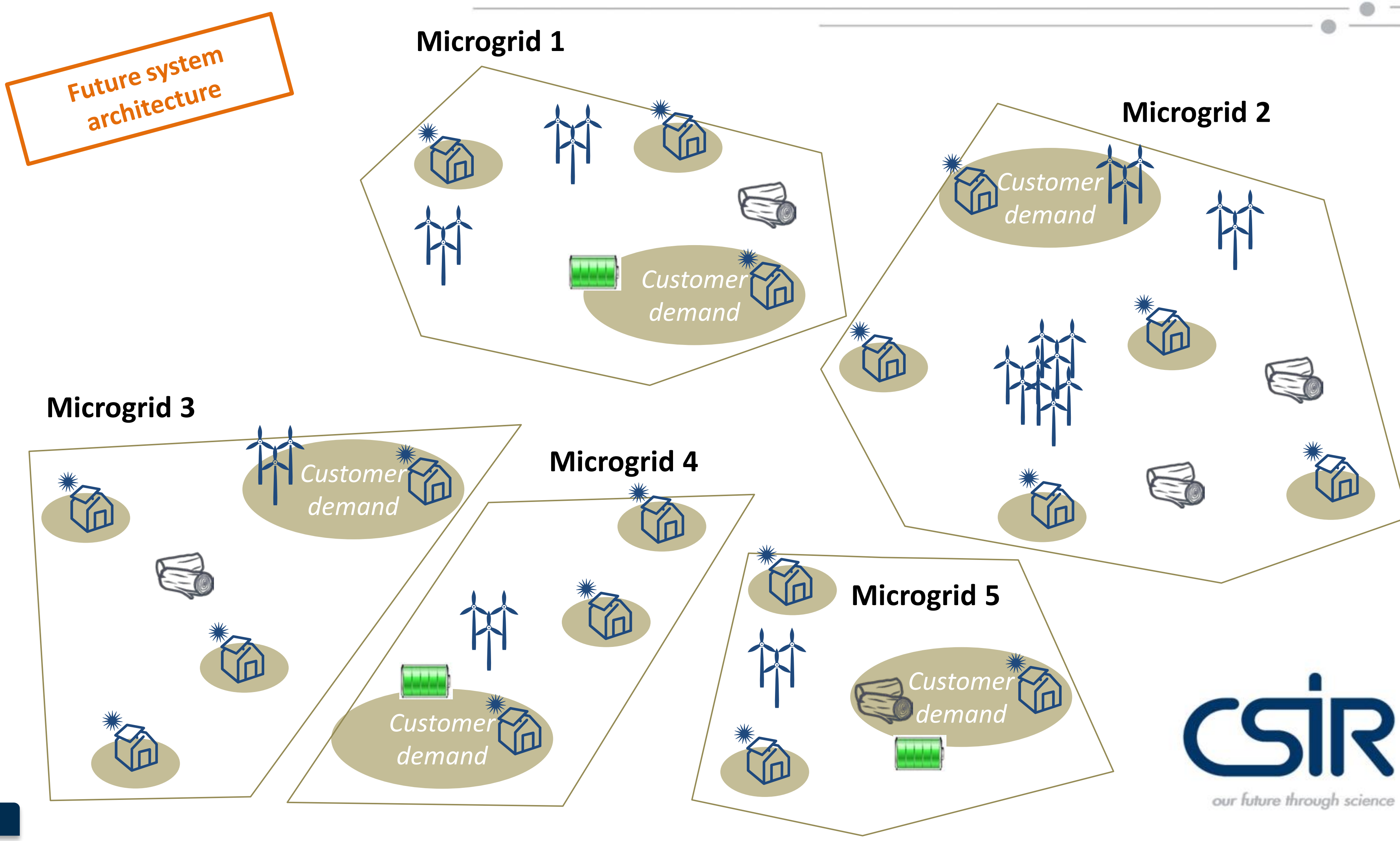
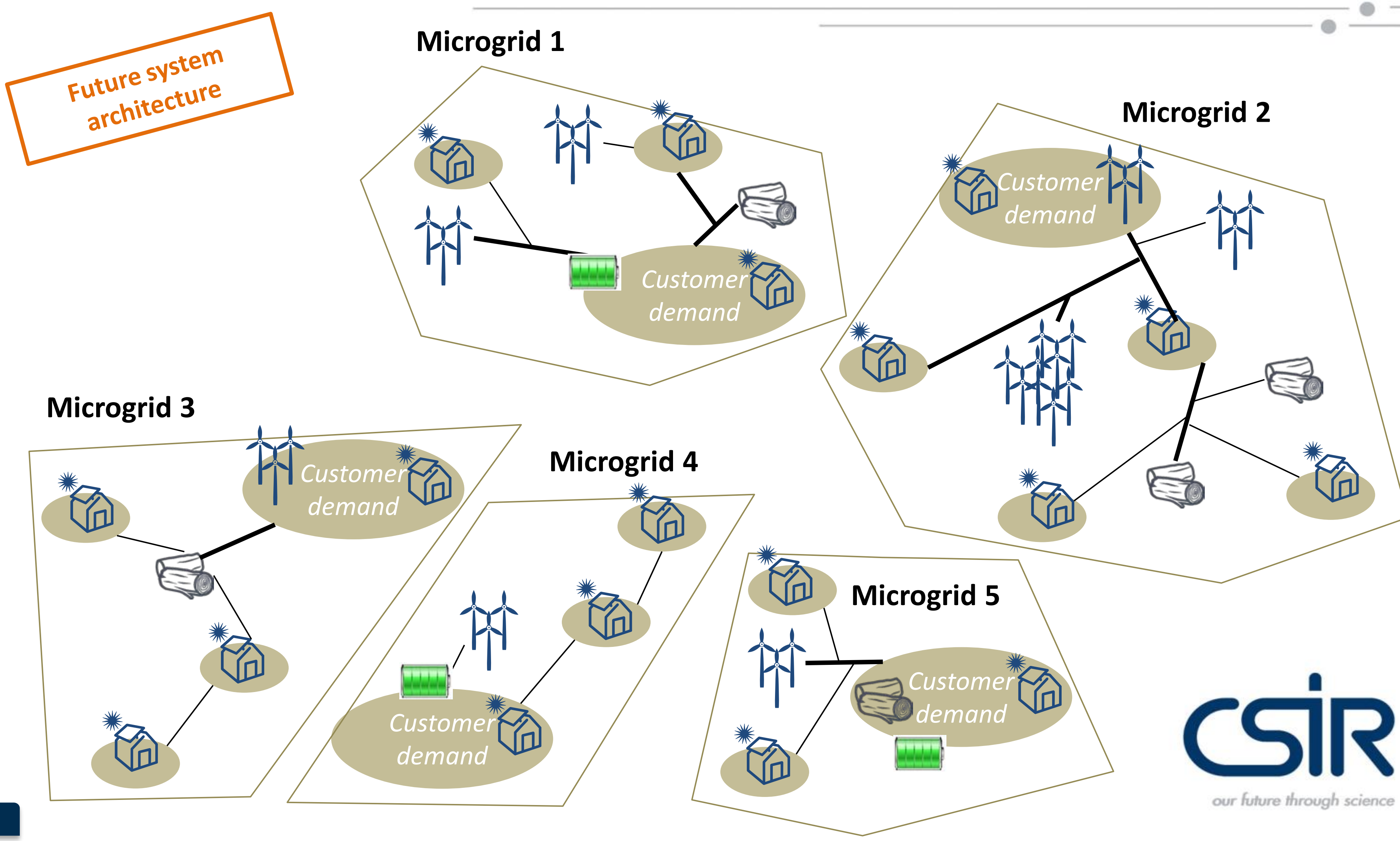
Flexible, dispatchable generators (biogas, biomass, diesel, natural gas, hydro, storage, etc.) will complement the local microgrid



Each microgrid can in principle run on its own...



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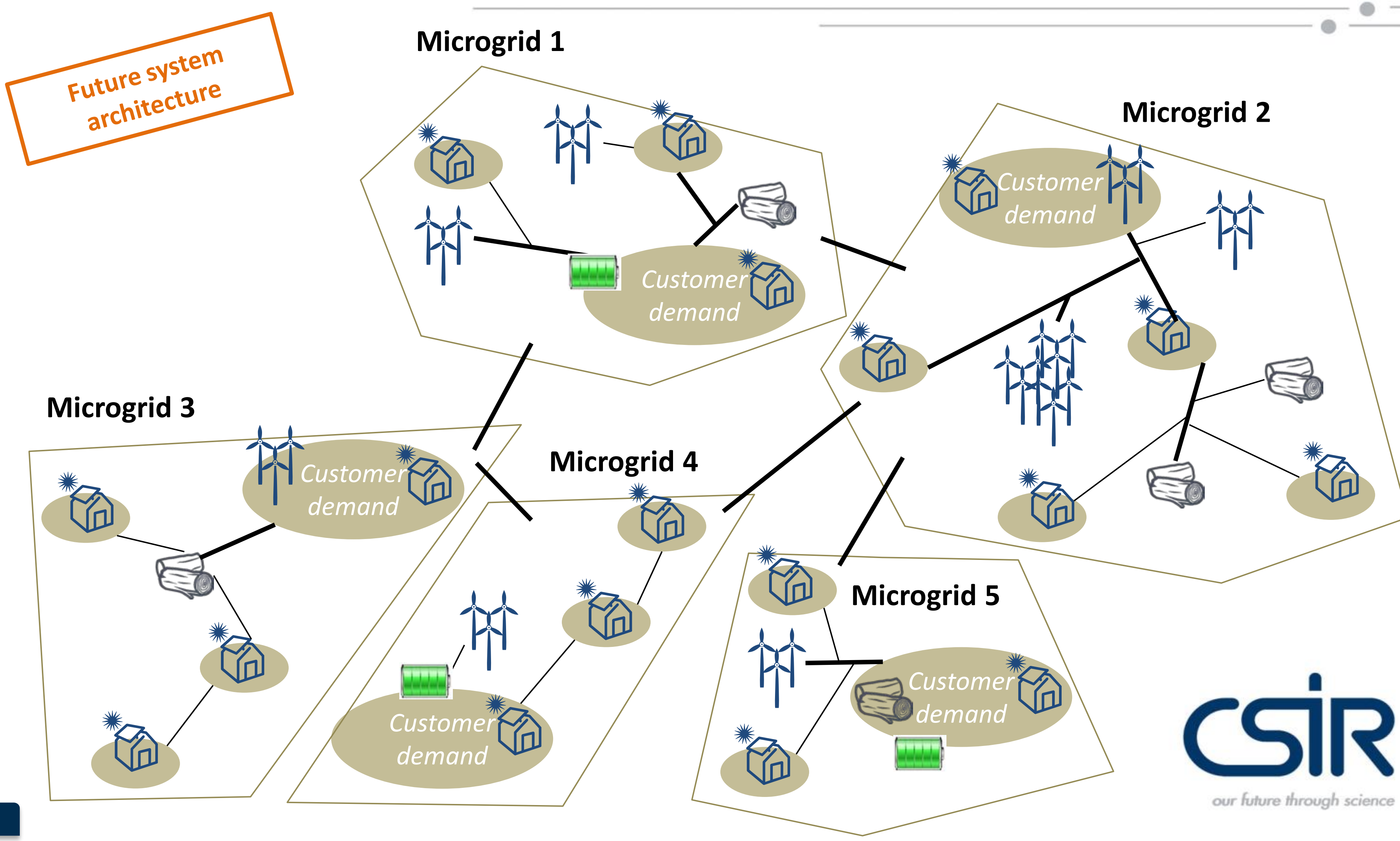
… but higher reliability & lower costs are achieved by interconnecting



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Opportunity for Africa: leapfrog large-scale, central power system architecture directly towards distributed, renewables-based system

Electricity use in kWh per person per year

Long-term target:
Demand for an economically prospering, yet energy-efficient country

Ø 8 000

"Old electricity world"

Central, big
- Coal
- Nuclear
- Natural gas

Traditional way to fill the gap

"New electricity world"

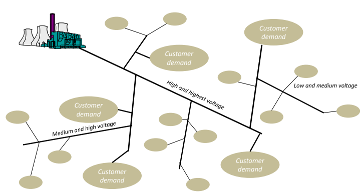
Distributed, smaller, flexible
- Wind
- PV (some CSP)
- Biomass/-gas
- Natural gas
- Hydro
- Geothermal (if feasible)

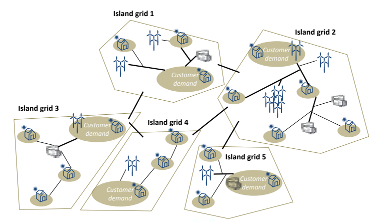
New alternatives to fill the gap

1 500

50

Actuals today
Range of African countries (excl. RSA)





Sources: World Bank; CSIR analysis

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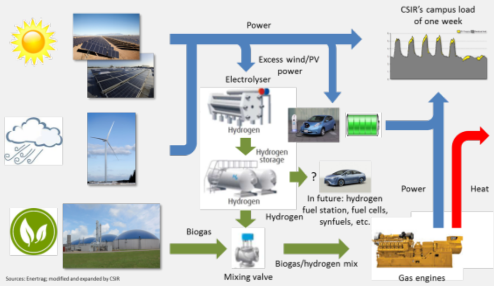
Energy-Autonomous Campus Programme

Real-world research platform for future energy systems and utility business models



Background

- Future energy systems will largely be based on Distributed Energy Resources (DER) – a combination of VRE, storage and demand response technologies
- Technology and systems innovations are required to design, build and operate such energy systems in an optimal manner
- The business model of utilities will also be affected

Response: Energy-Autonomous Campus Programme

The CSIR started a programme where it implements in the real world its research findings as a test bed for future energy systems

- Demonstrate how to cost-efficiently design and operate an energy system based on distributed, VRE technologies
- Implementation across all CSIR campuses, potentially further integration of other research campuses
- Integration of energy storage in form of batteries & hydrogen
- Energy savings and demand response opportunities
- Key outcomes: System design/operations, technology demonstration, future utility business model

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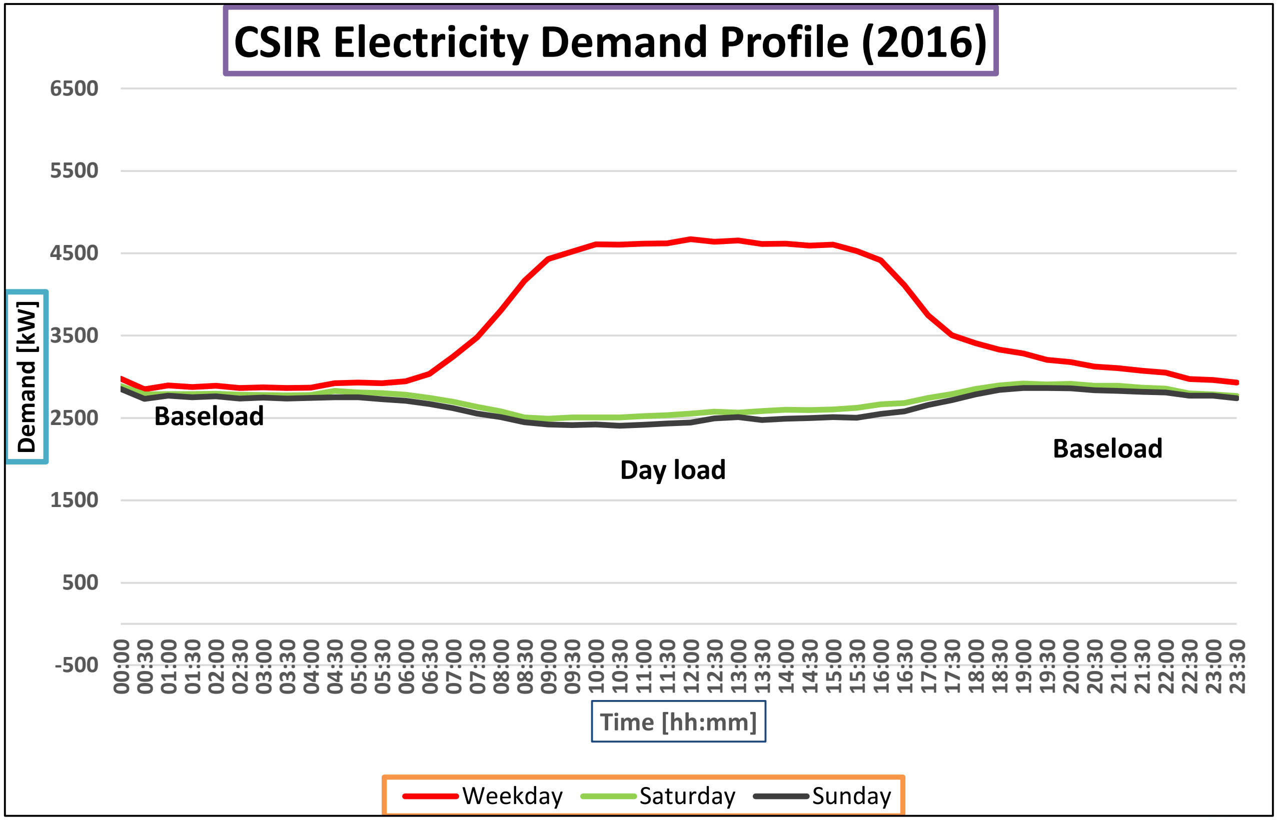
Energy-Autonomous Campus Programme

The Pretoria Campus load



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Energy-Autonomous Campus Programme

Potential future campus energy mix

Demand and consumption

Reduce Consumption : 20% reduction through energy efficiency (30 GWh) → 24GWh) per year

Load Management : Through Demand Response (DR) measures including Electric Vehicles

Supply

PV: All CSIR rooftops, 1-2 ground-mounted plants
Total of 8 MWp → 13 GWh/yr

Wind: Baseload 3-4 MW-class wind turbines
Total of 3 MW → 7 GWh/yr

Biogas: Municipal/organic waste from surrounding supermarkets/restaurants
4-5 MW @ 800-1,000 hrs/yr → 4 GWh/yr

Trading with Tshwane municipality (import and export) based on pure economics

Storage

Power-to-H2: For long-term storage of excess renewables

Batteries: For short-term peak shaving

Heat storage: For flattening of heat/cold demand

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Current activities

Wind Turbine:

Wind Assessments & Feasibility studies

Biogas plant:

Feed stock analysis,

Site selection,

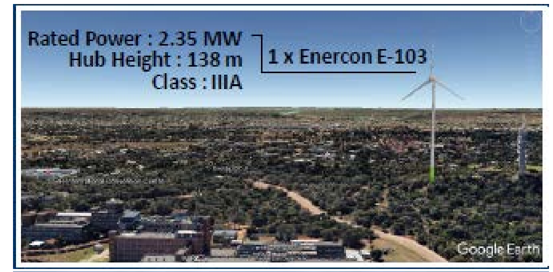
Environmental Impact Assessment, etc

Demand side management:

Campus energy audit & street light energy audit

Storage:

Technology selection process, procurement of electric vehicles for the campus



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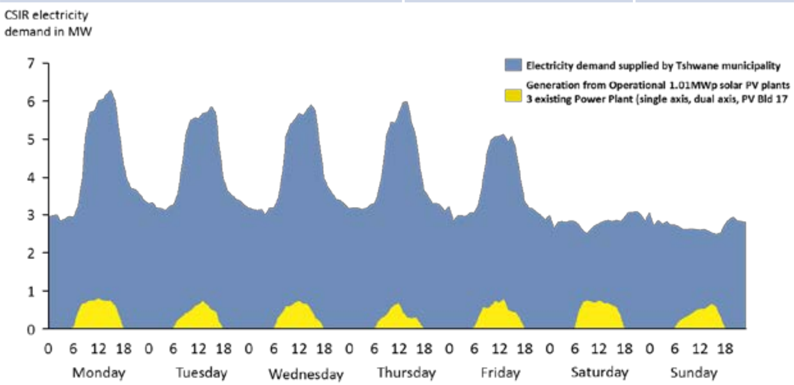
Over 1 MW of Solar PV installed to date

Project	Size	Commissioned	Investment	Savings in 2016
1. Solar PV plant (1-axis)	558 kW	August 2015	$770,000	$80,000
2. Solar PV plant (2-axes)	200 kW	November 2016	$500,000	Start-up
3. Solar PV plant (rooftop)	250 kW	March 2017	$320,000	N/A



Real world platform for researchers

CSIR's Energy-Autonomous Campus

- Platform for CSIR researchers and partners (companies and universities) to optimally design, implement and operate microgrids and to demonstrate new energy technologies in a real-world environment

Typical Services and Solutions on the Energy-Autonomous Campus

- Installation and operational guidelines for renewable power
- Procurement guidelines for renewable plants
- Smart and Micro Grid design and operation guidelines
- Installation and operational guidelines for battery storage systems in micro grids
- Test bench for new renewable technologies

Additional CSIR Energy Systems research work

- Development of Integrated Resource Plans for cities, regions, countries
- Development of operational guidelines and procedures for high-RE power systems

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Re a leboha

Ha Khensa

Enkosi

Siyathokoza

Thank you

Re a leboga

Ro livhuha

Dankie

Siyabonga

Note: "Thank you" in all official languages of the Republic of South Africa