THE ROLE OF HYDROGEN AND FUEL CELLS IN DELIVERING ENERGY SECURITY

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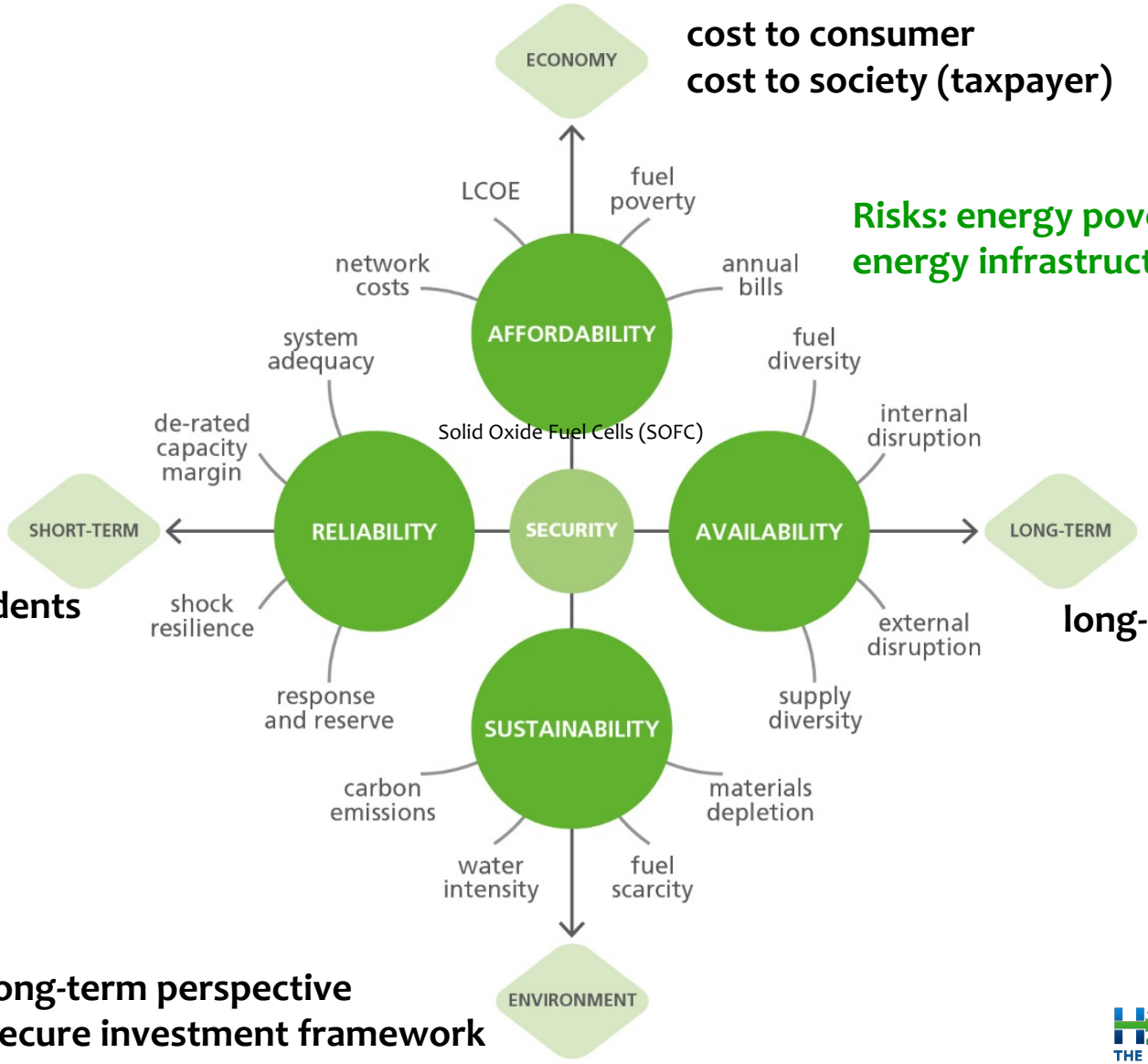
Energy Security Definition(s)

how can hydrogen and fuel cells contribute to energy security in the energy system?



cost to consumer
cost to society (taxpayer)

Risks: energy poverty, loss of access, energy infrastructure disruptions

resilience
robust to incidents

robustness
long-term stability

long-term perspective
secure investment framework

Hydrogen Production: Variety of Sources

Achievement: increase in choice of feedstock

Electricity	→	η = 66% **Electrolysis**	→
Natural Gas	→	η = 85% **Reforming**	→
Crude Oil	→	η = 65% **Reforming**	→
Biomass / Wastes	→	η = 55% **Gasification**	→
Sunlight + Nutrients	→	η = 5% **Bacteria**	→

HYDROGEN

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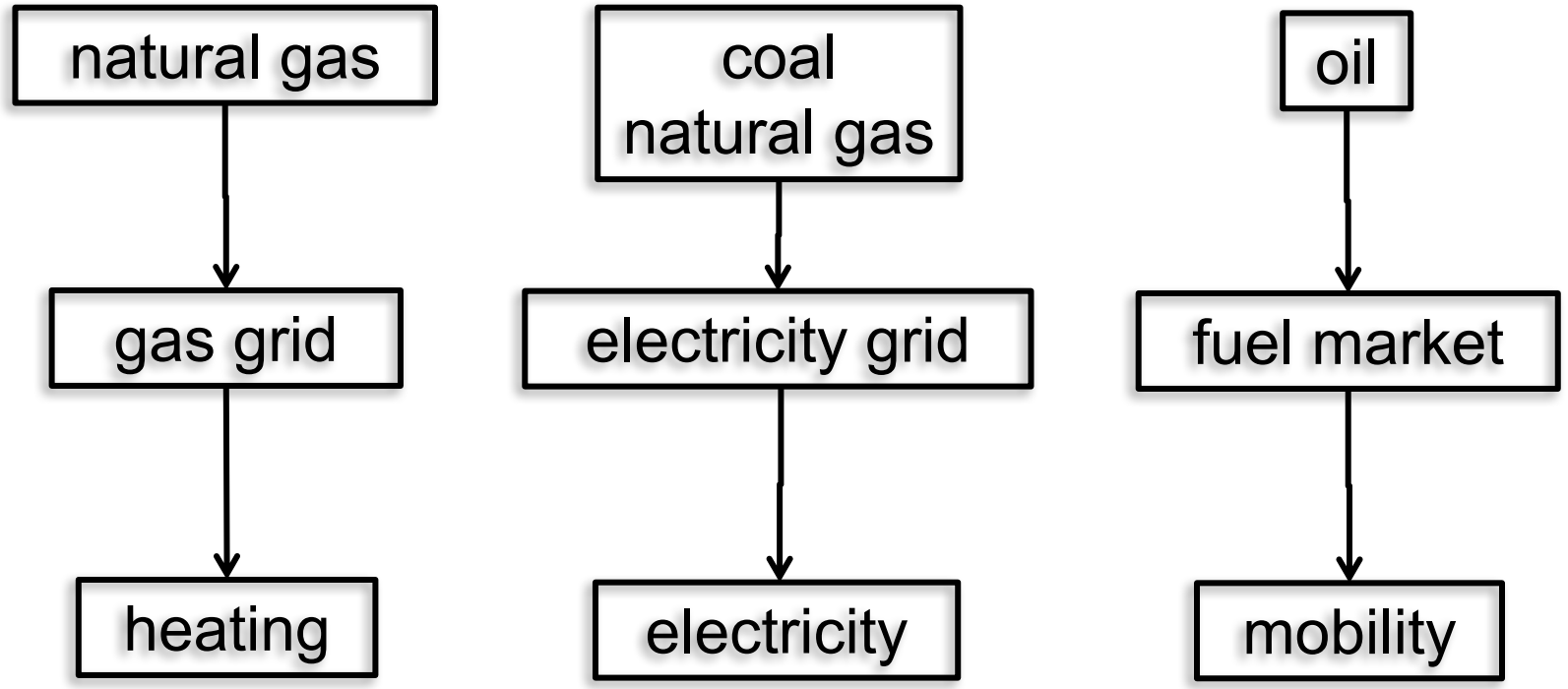
Energy Security – By Adding Flexibility

* Adopting hydrogen increases energy diversity.
* Hydrogen can be produced using a range of feedstocks/processes, including renewable electricity and biomass.
* Price volatility of energy sources or supply disruptions can be ameliorated by switching to alternative feedstocks.
* Energy imports can be reduced due to increased renewable energy employment, reducing political & economic dependence.

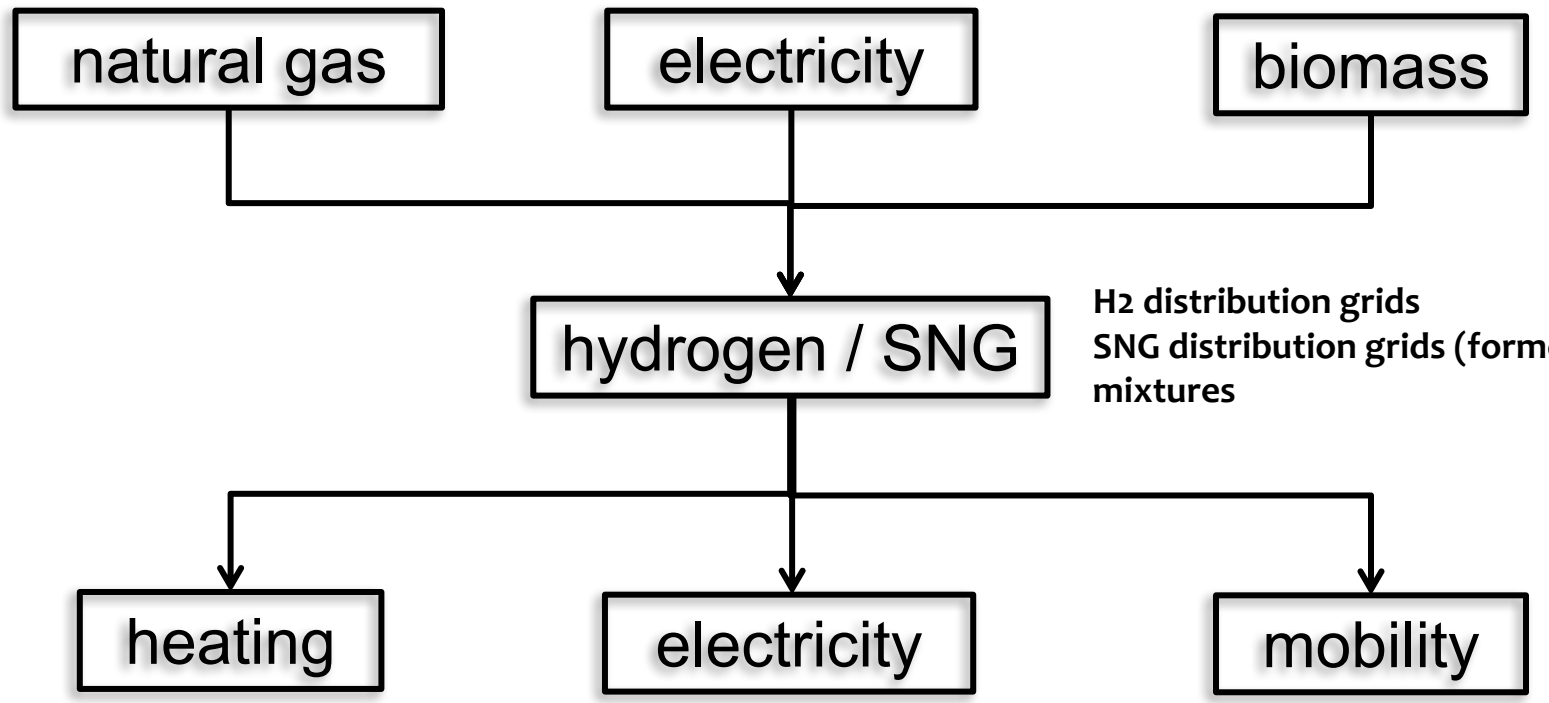
Conventional Energy Infrastructure

Risks: import dependence, loss of GDP to imports, political influencing

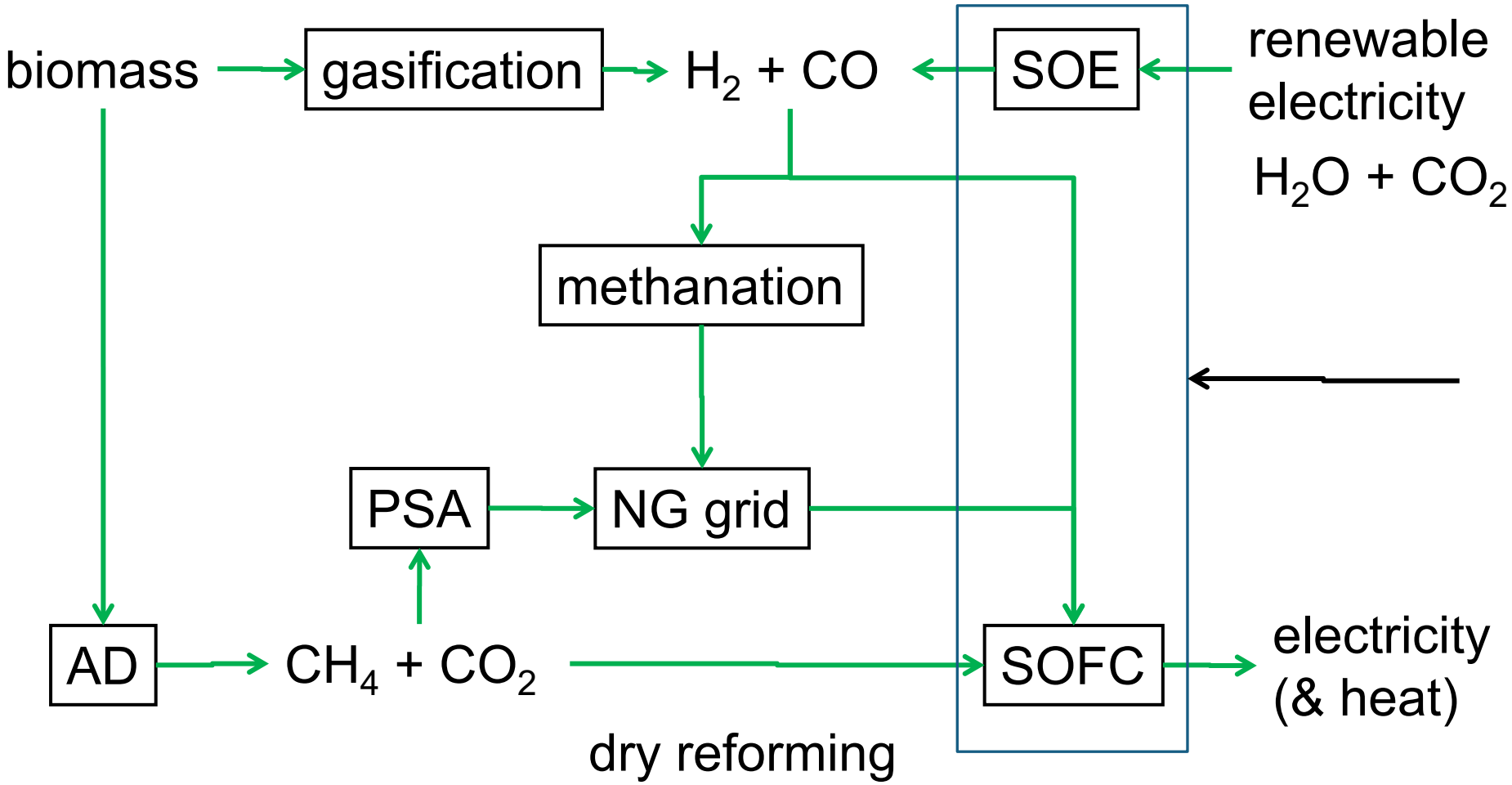


Future Hydrogen Energy Infrastructure

Achievements: increase in flexibility, reduction in import dependence, reduction of supply shortages



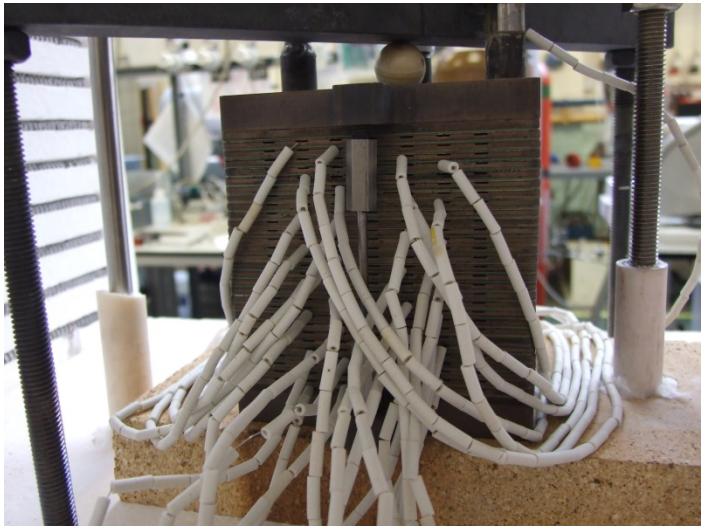
An Ultra-Low Carbon Recycling Scenario



Hydrogen to Energy: Fuel Cells

Achievement: reduction in energy dependencies due to more fuel options

* Solid Oxide Fuel Cells (SOFC) convert a range of fuels from hydrogen over methane (natural gas), town gas (H_2 + CO), propane, and methanol, up to ethanol
* 'internal reforming' converts hydrocarbon fuels (methane etc.) internally by recycling heat
* result: very high electrical efficiencies >60% (net)



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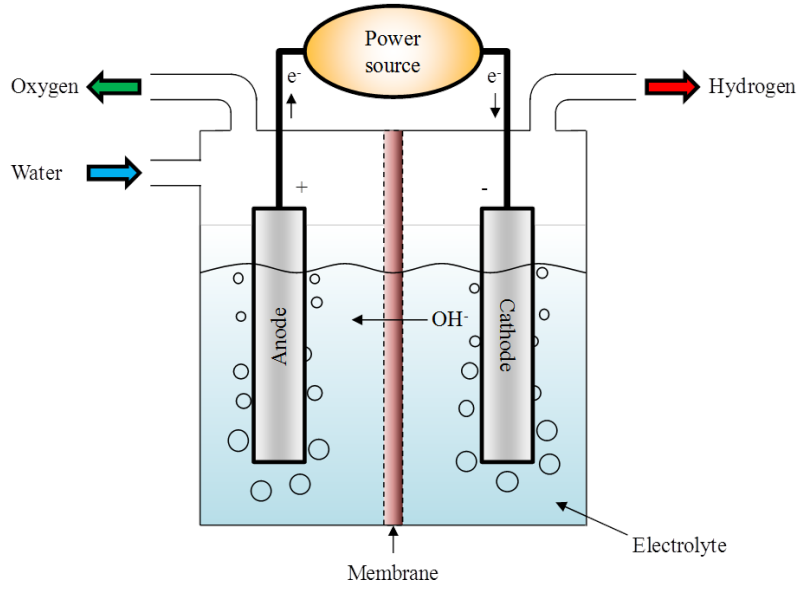
Enabling Technology

Achievement: novel options for safe operation of buildings and electricity grids

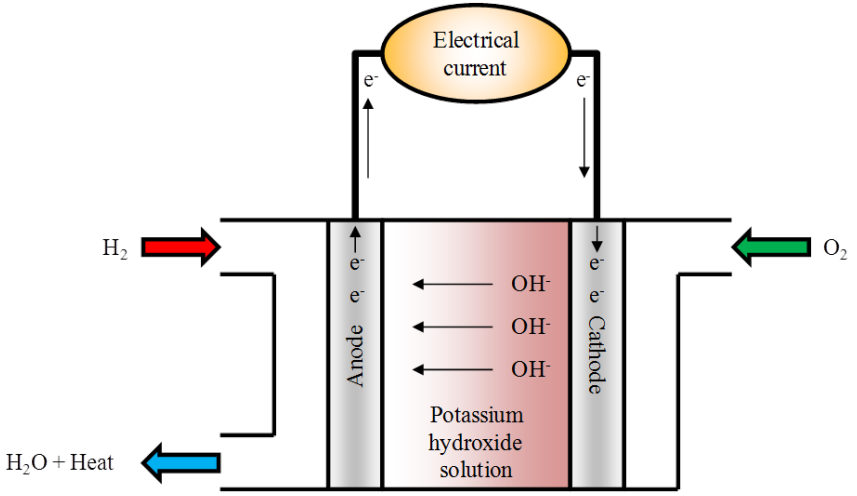
* supply of grid support from Fuel Cell Electric Vehicles (FCEV)
* building electricity backup from FCEV
* linking electricity grid and gas grid
* supplying portable power and off-grid power

Reversible Fuel Cells

* electrochemically speaking, fuel cell and electrolyser are the same device, run in two different directions
* integrating fuel cell and electrolyser in the same unit allows to support electricity grids with high renewable energy input at reduced investment



alkaline electrolyser converting electricity & water to hydrogen



alkaline fuel cell converting hydrogen to electricity & heat

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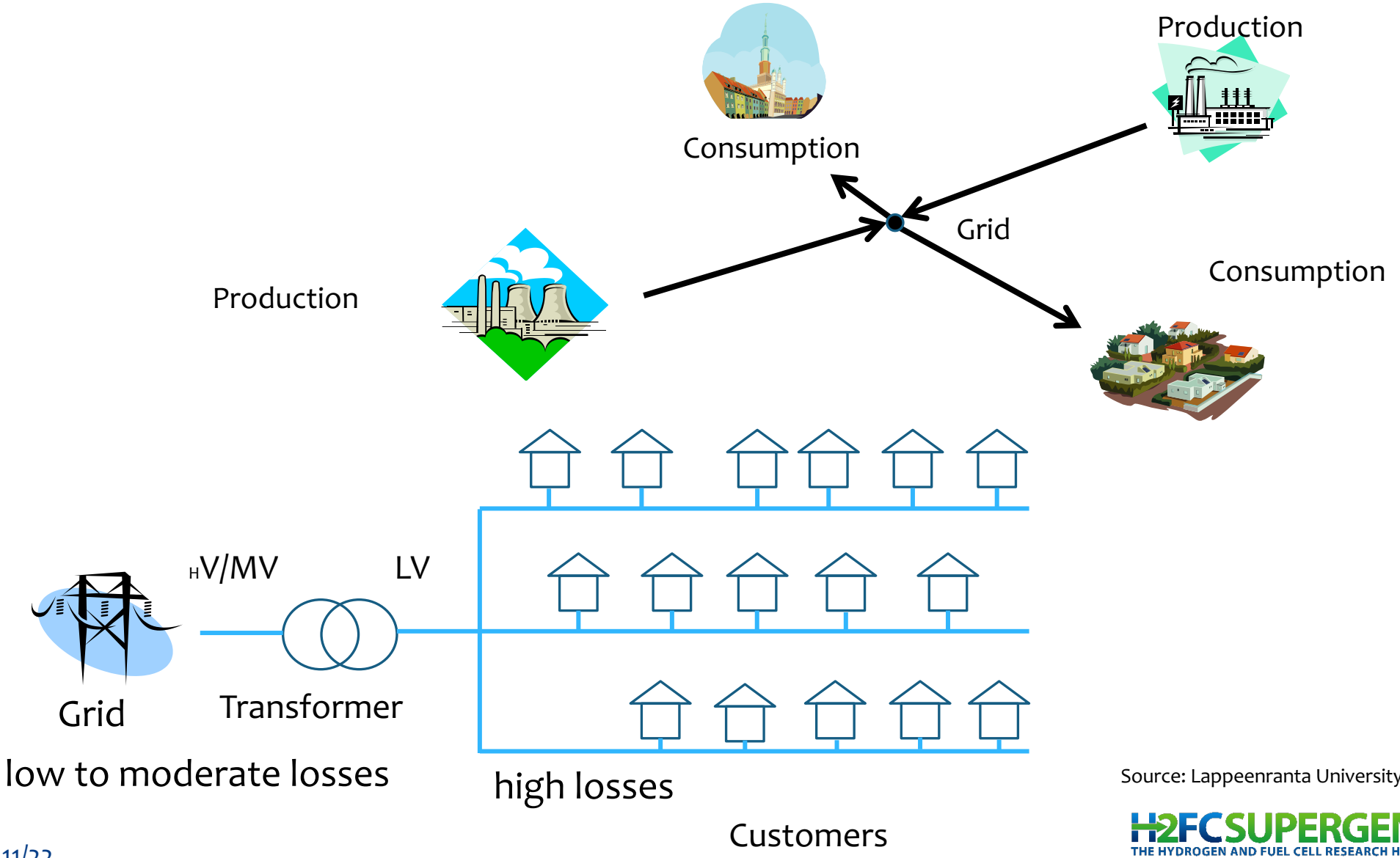
Traditional Electricity System



Source: Lappeenranta University

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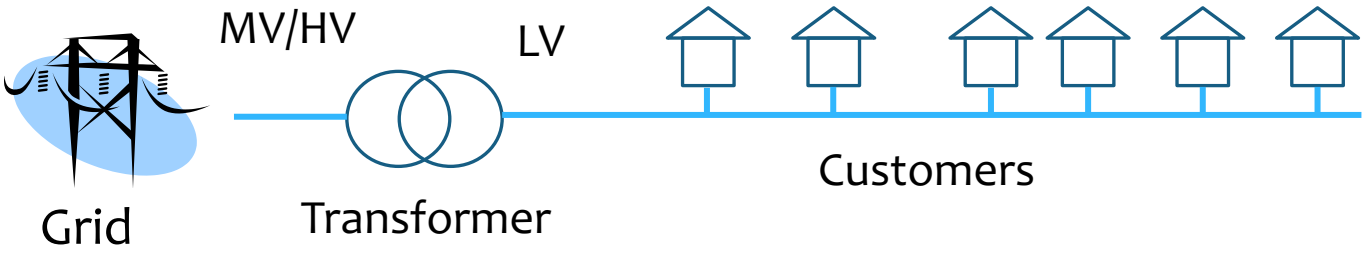
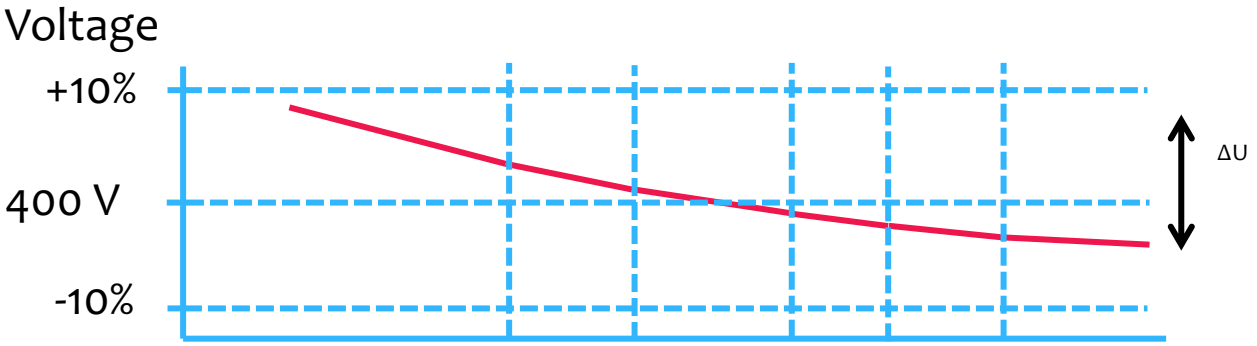
Local Distribution





Losses $P_L = \Delta U * I = R * I^2$

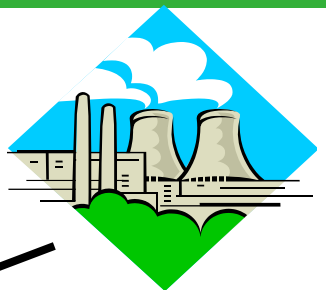
$\Delta U = R * I$

Source: Lappeenranta University

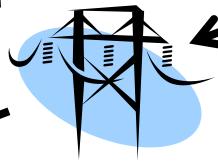
Decentralised Electricity System

Consumption

Production



Grid



Grid Node

Dec. Production

Dec. Production

Consumption

modified from: Lappeenranta University

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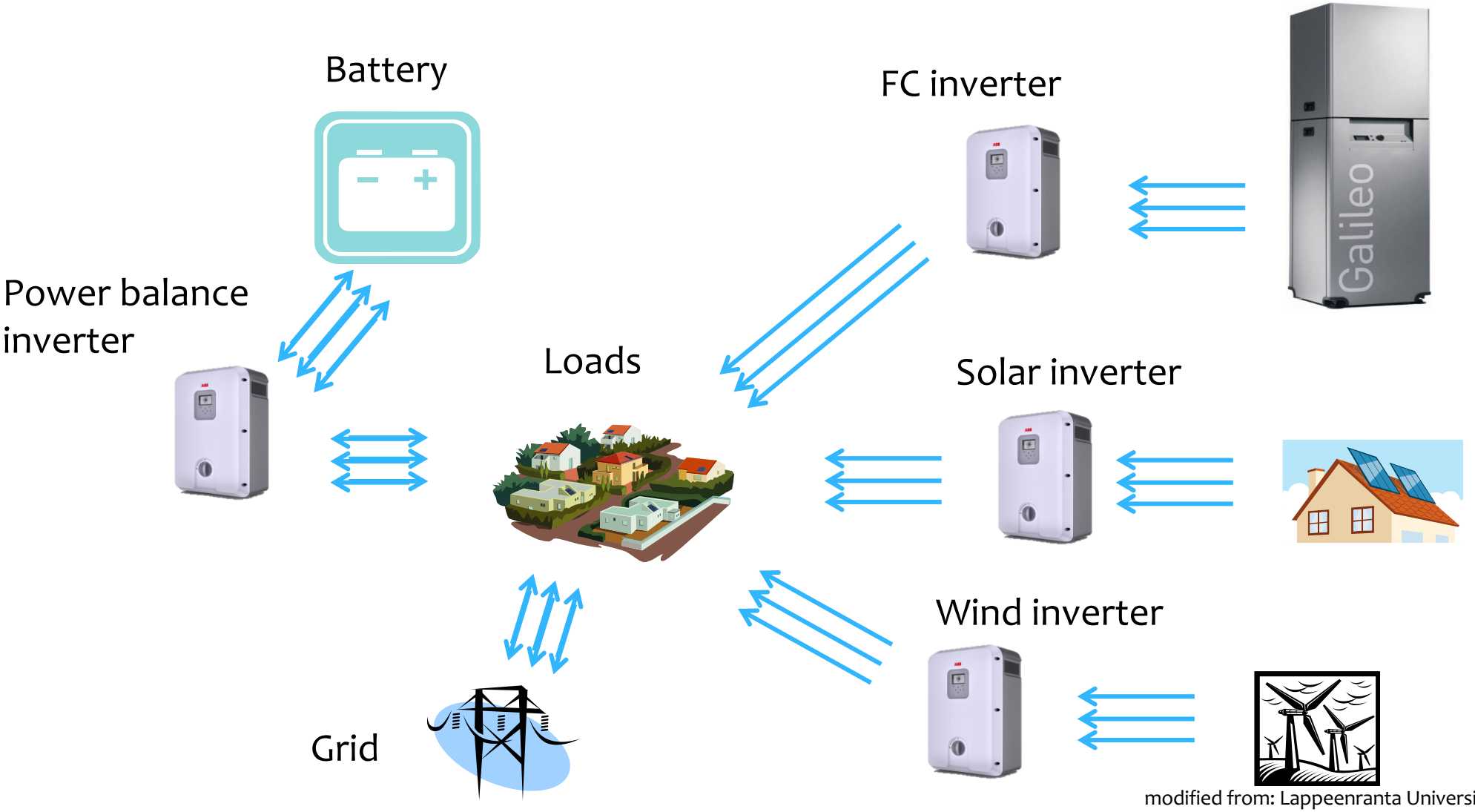
Distributed Energy Systems



modified from: Lappeenranta University

Effects of Decentralised Electricity Generation

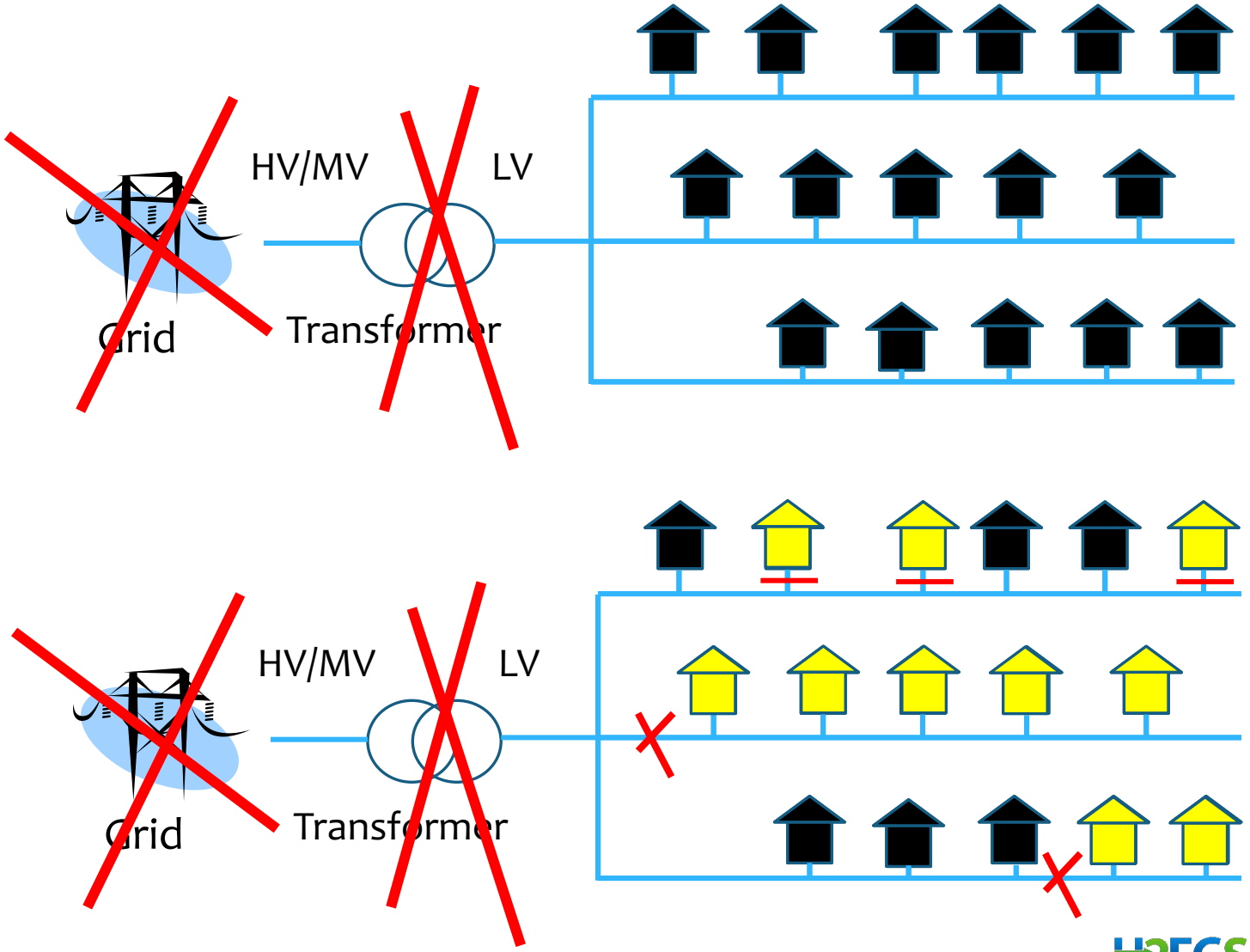
Advantages:

- Less transmission losses (up to 10% in low voltage grid)
- No need for new electricity lines as the local power demand rises
- Better reliability during grid disturbances (islanding)
- Self-sufficiency in energy

Disadvantages:

- Complex systems
- Grid maintenance becomes complex

Resilience of Distributed Systems



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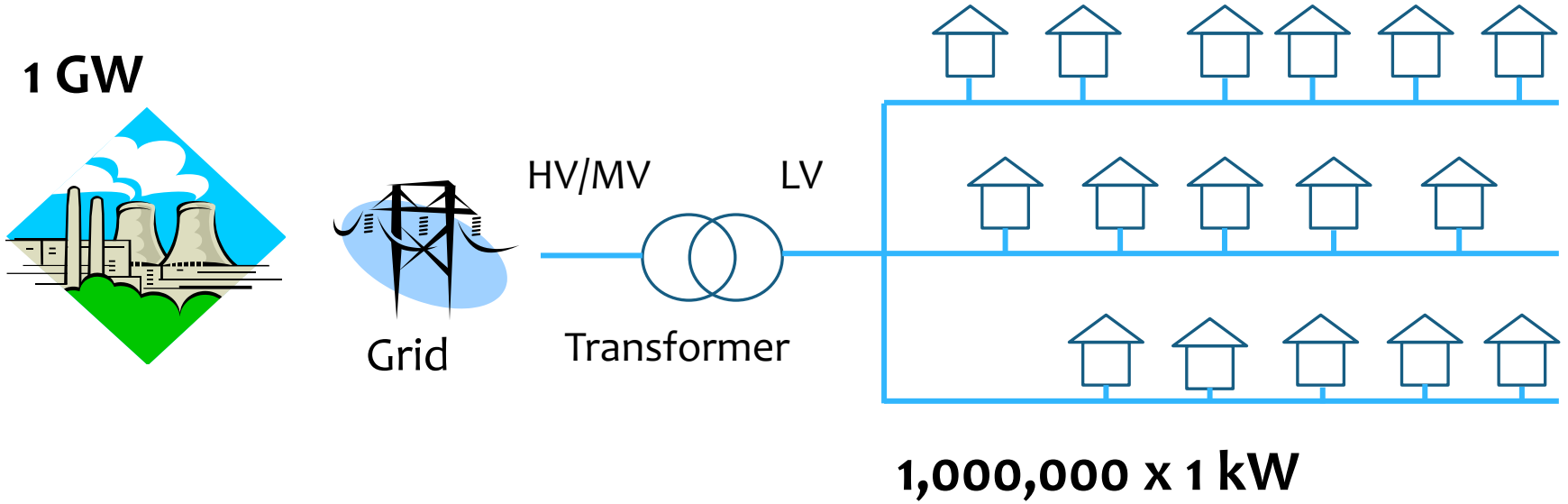
Cyber Attack on Distributed Systems

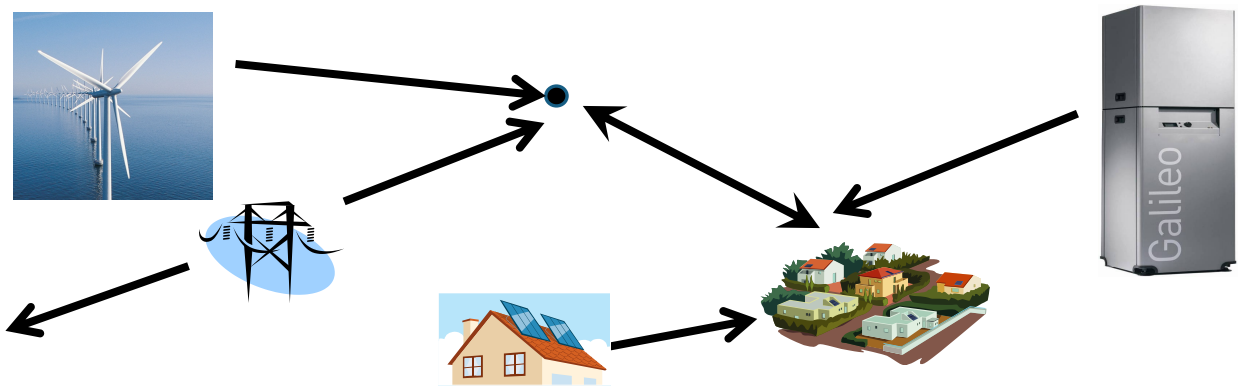


- impact of cyber attack on central power station or grid very high
- impact and probability of CA on residential CHP very low
- effort of hacking 1,000,000 systems
- possible low level of protection of µCHP (Windows OS) and common software
- threats of Internet of Things

Decentralised Fuel Cell Infrastructure

Fuel cells support grid functions with respect to

* Reduced distribution losses,
* Increased reliability due to lower probability of total disruption,
* Blackstart capability and the option to ‘island’ parts of a grid that are still intact following an outage,
* Increased fuel flexibility by allowing for a variety of fuels, many of which are generated from renewable energy sources.



Politics of Energy Security

* Energy security policy focuses on access to fossil fuel resources and on operating a stable electricity system. Other parts of the energy system receive very little attention.
* The policy focus is short-term – the next 5 years.

* Low-carbon energy systems tend to be more infrastructure-intensive than existing systems. Investments we make now in long-lived infrastructure could have long-term impacts on energy security.
* There is a need to consider the long-term implications of moving to a low-carbon system on energy security.

Policy Support

* Holistic approach to energy systems to develop a low-carbon and flexible energy system, with hydrogen and fuel cells included.
* Implementation of a ‘system architect’ or ‘clearing house’ as a coordination body for an increasingly complex energy infrastructure.
* Policy incentives that create a level playing field for hydrogen and fuel cells.
* Policy indication on the future strategy for supplying heat and power to homes, businesses and industry.
* Increase funding for research on hydrogen and fuel cell technologies.

H2FC Potential

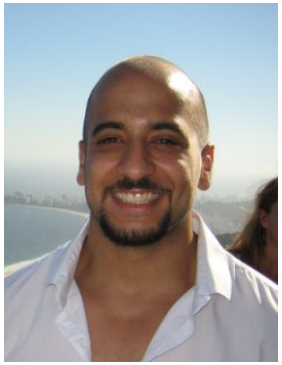
* how can hydrogen and fuel cells contribute to energy security in the EU energy system?

Like this:

* increasing the EU independence from fossil and imported energy sources,
* increasing the stability of the EU economy by greatly reducing the risk induced by volatile energy import prices,
* increasing the resilience of EU energy supply by reducing the risks from damage to the infrastructure (by natural incidents as well as malevolent interference).





Thanks for your Attention!

Any Questions?

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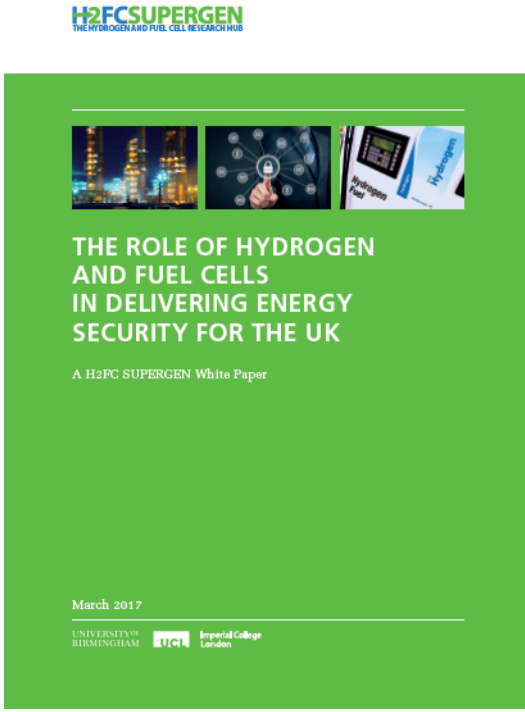

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