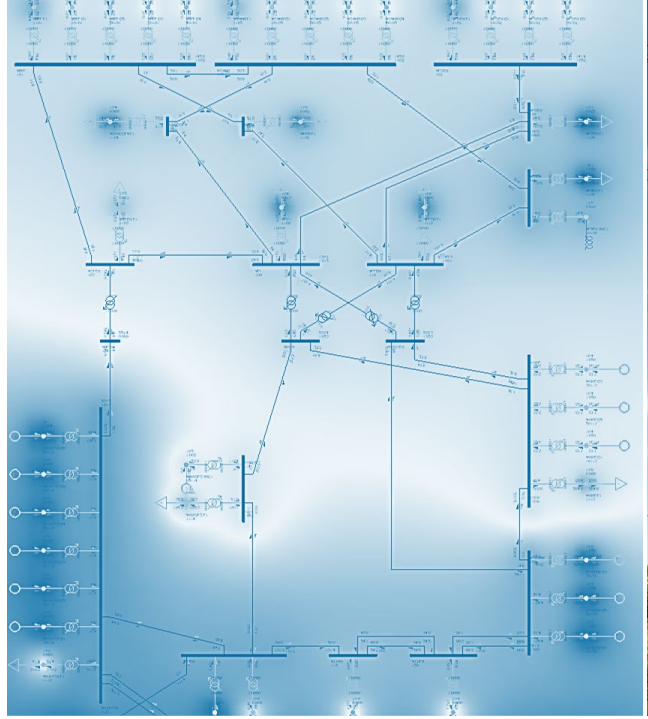


micro vs MEGA Grids:

Trends Influencing the Development of the Power System

Emil Hillberg

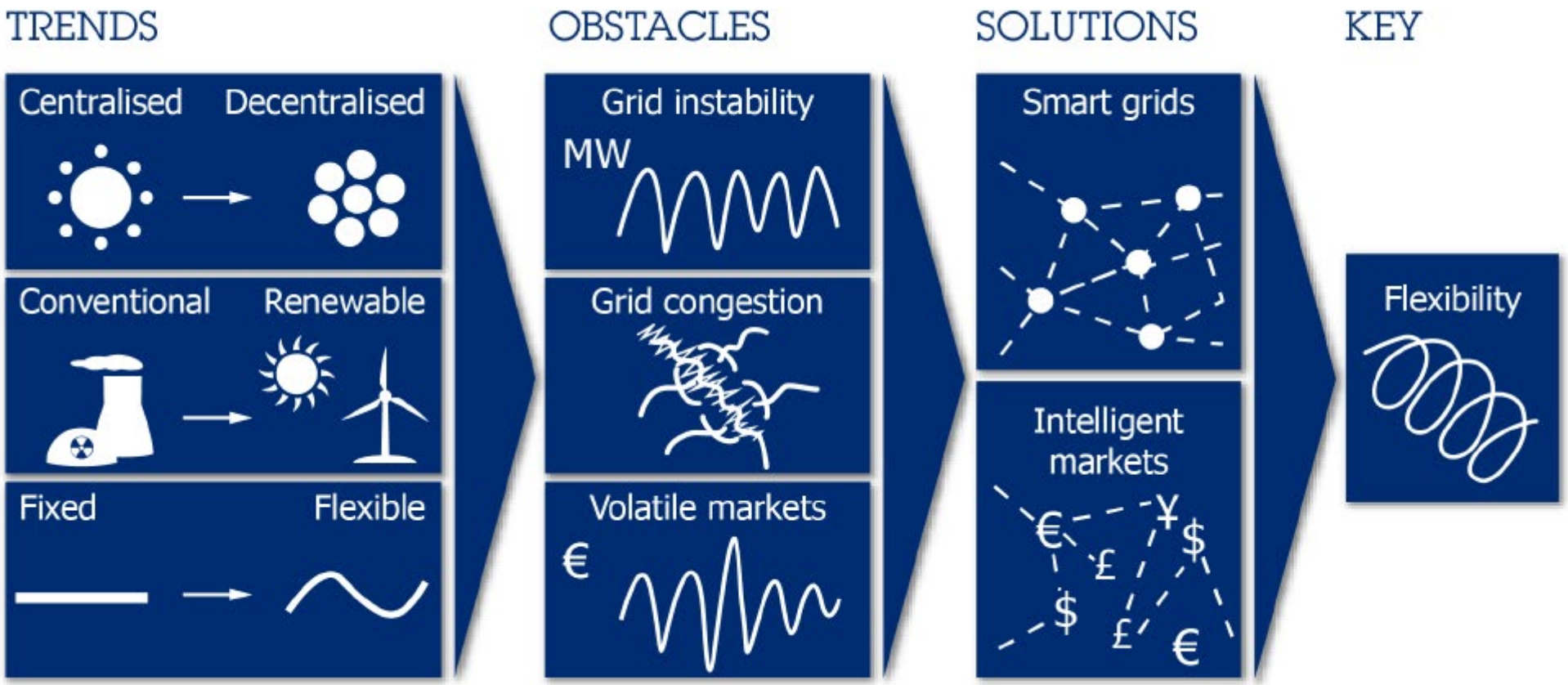
September 2019

RISE Research Institutes of Sweden

Agenda

- An Evolving Power System
- Power Grid Development From A Historical View
- Decentralization Trend
- The Future Power Grids
- Summary

An Evolving Power System



GRIDS?

An Evolving Power System

- Three tipping points leading to disruption:
  - **PV & BESS on customer level**:
    when this is the economical solution there is no need for other production types!
  - **Electric Vehicles**:
    when cost parity with combustion engine vehicles, “all” new vehicles will be EV!
  - **Local energy**:
    when this meets cost parity with the transfer cost, we will have no need for a GRID…

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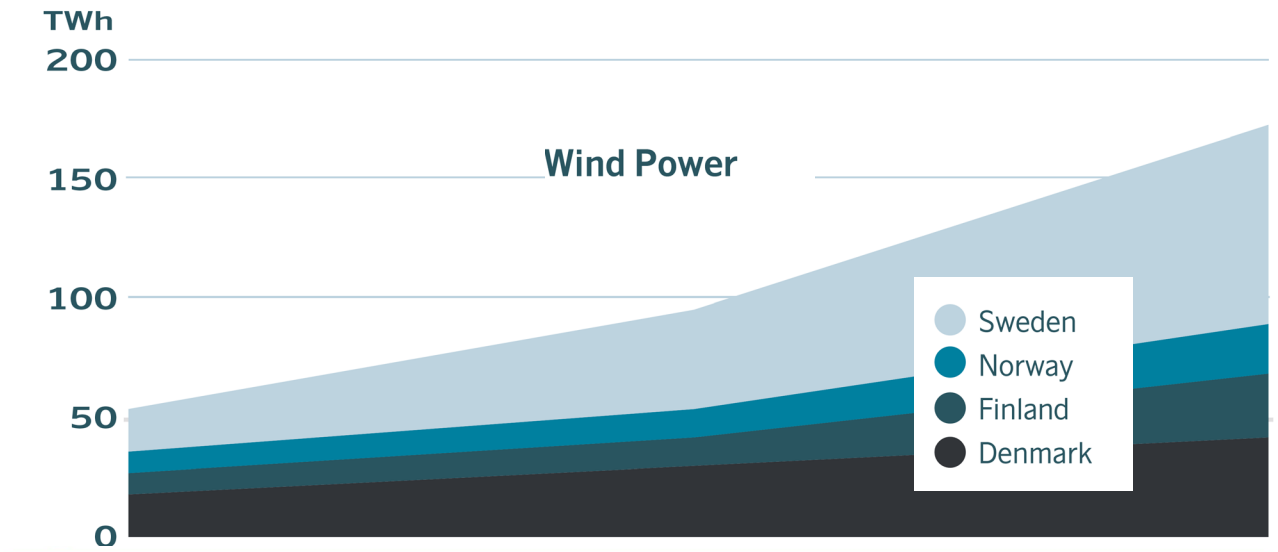
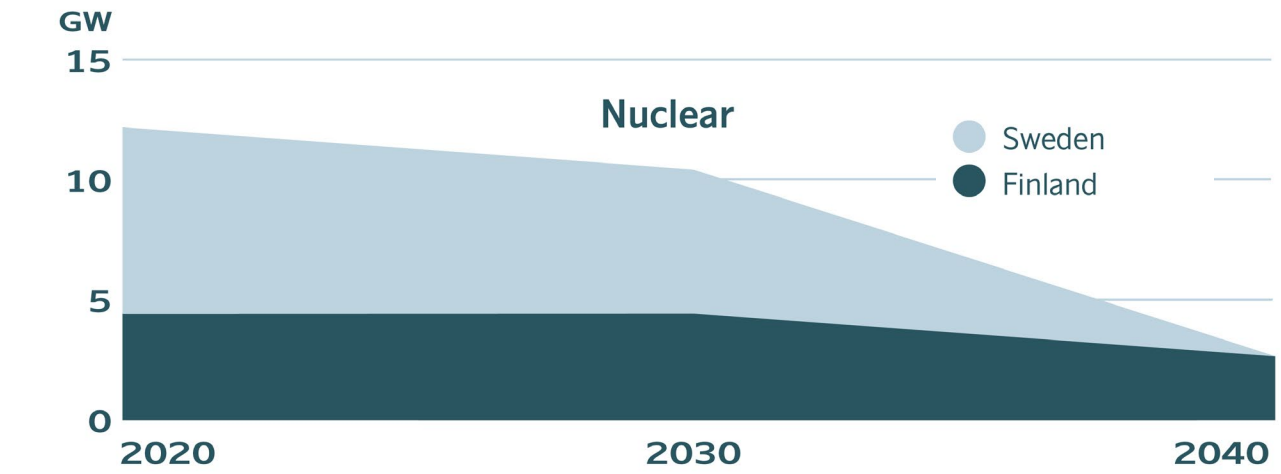
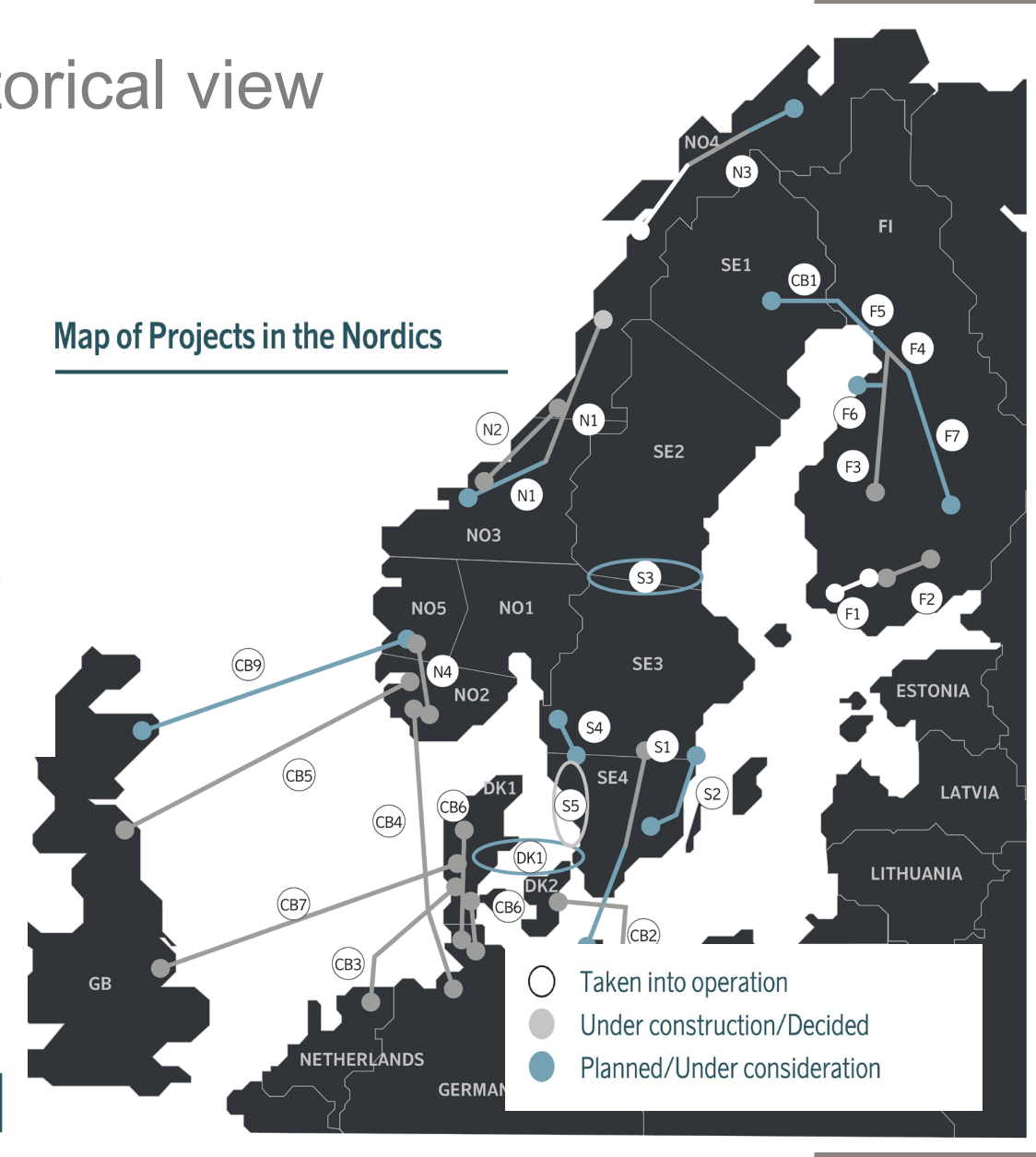
Power grid development from a historical view

- Perspective: Top-down, (inter-)national, (intra-)system wide
- Planning horizon: Long term, ten-year network development plans, + 40 years equipment lifetime
- Investment levels: Utility scale production and transfer multi-MW to GW units multi-kV to MV levels
- Number of actors: FEW
- Decisions factors: Socio-economic acceptable solutions, National equality “single national price level for energy” (limit bottlenecks between production centers and load centers), Trading capabilities through international connections
- Dreams: Multinational “Super grids”- Medgrid, NorthSeaSuperGrid…

Power grid development from a historical view







(Nordic TSOs 2019)

Power grid development from a historical view

- Drivers
  - Social economic welfare: Reliable **electricity supply is a basic right for all**
  - **Reinvestments** needs to maintain existing capacity (aging assets)
  - Grid investments for **production and load development**: Integration of new generation, decommissioning of present units, growth and change in consumption
  - **Trading**
  - **Economy of scale**: Cheaper (per MWh) and more efficient with larger installations
  - **National strategies & policies**: Nuclear power, UHV power transmission, etc.
  - **CLIMATE GOALS**
- Challenges
  - **Long term investments** in a changing environment: Risk for stranded investments, technology commitment with technology development at an unprecedented pace…
  - **Social acceptance**
  - International relations: Building in **dependency of other nations**

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Decentralization Trend

- Perspective: Bottom-up, local / regional system, urban development
- Planning horizon: Short term, fast decisions, short installation time, <10 year equipment lifetime
- Investment levels: Small scale production and distribution kW to MW units V to kV levels
- Number of actors: MANY
- Decisions factors:
  - Lead-time for larger investments
  - Local acceptance
  - Energy prices vs investment levels
- Dreams: Local autonomy, independency, self sufficiency and sustainability

Decentralization Trend

AKADEMISKA HUS

CHALMERSFASTIGHETER

CHALMERS

Göteborgs Stad

ERICSSON

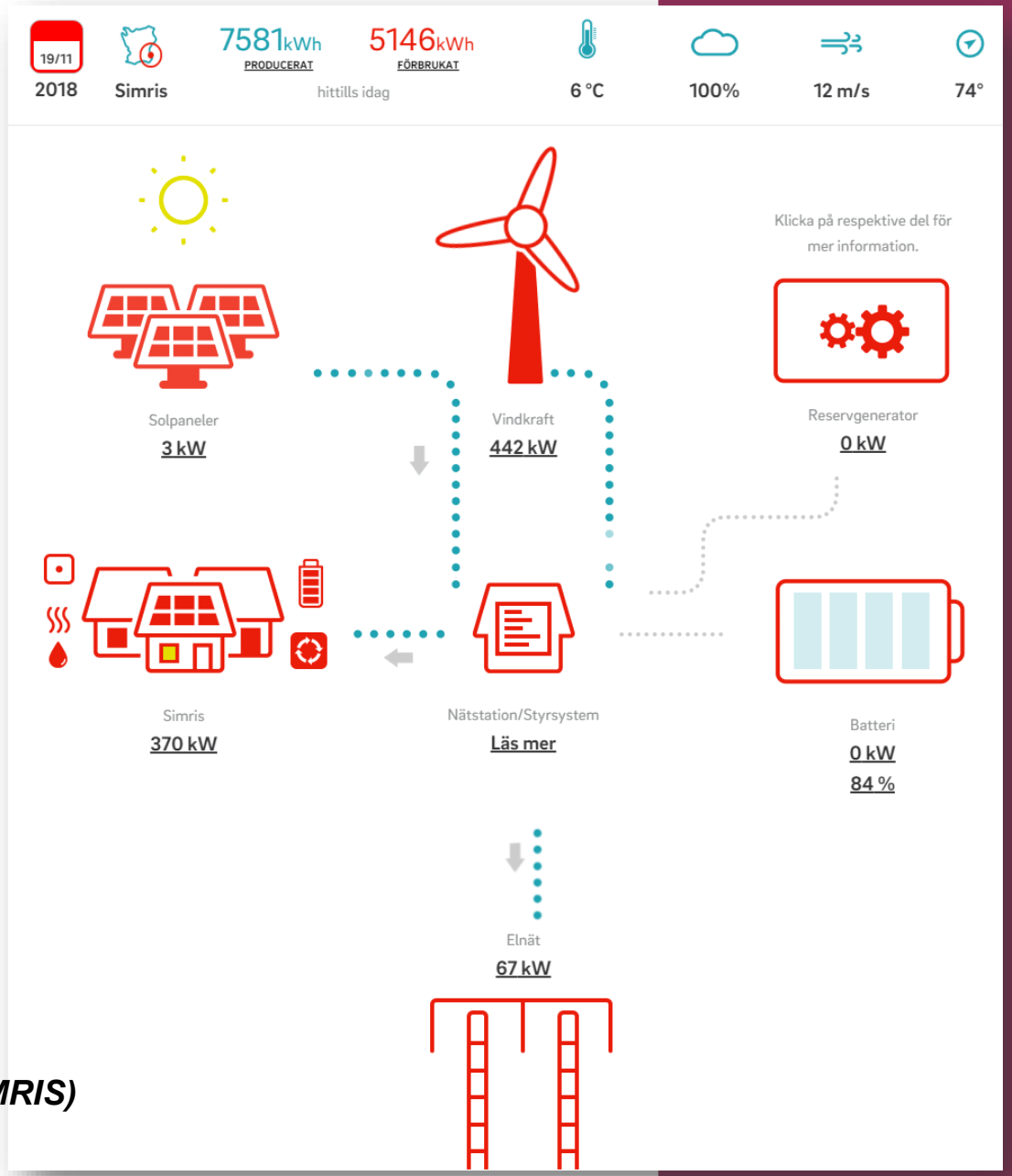
EUROPEAN UNION

UIA URBAN INNOVATIVE ACTIONS

Göteborg Energi

Johanneberg Science Park

BUSINESS REGION GÖTEBORG

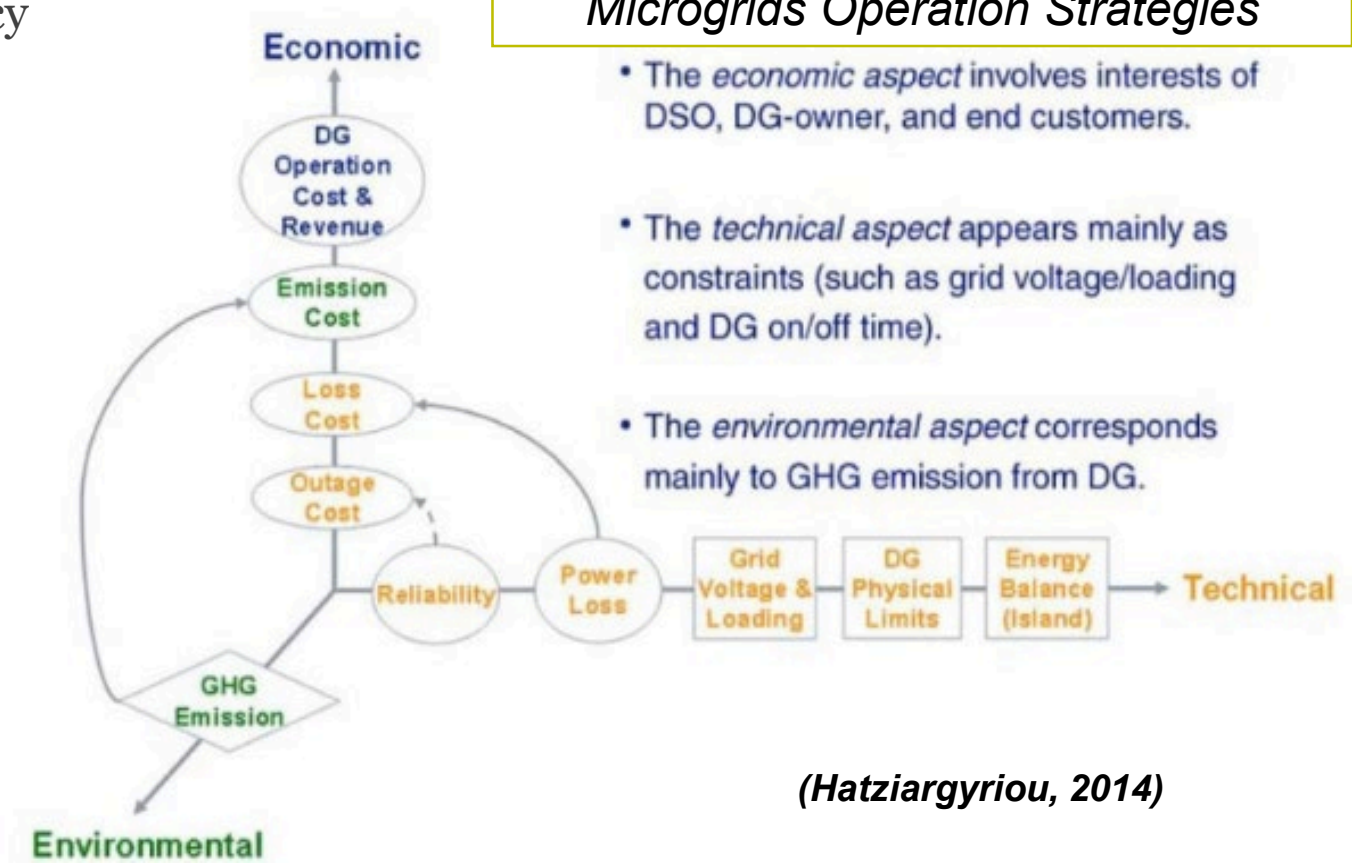


(FED) *(SIMRIS)*

Decentralization Trend

- Drivers:
  - Social economic welfare: **Electrification of remote areas**
  - Technology and price: **Economy of scale insignificant**
  - National strategies & policies: **Subsidiaries** for micro-producers etc…
  - Local factor: **Self-sufficiency**/independency
  - **CLIMATE GOALS**
- Challenges:
  - **Interoperability**
  - **Number of units** participating in a market
  - **Operation** and resilience
  - **Social injustice**

Microgrids Operation Strategies



- The *economic aspect* involves interests of DSO, DG-owner, and end customers.
- The *technical aspect* appears mainly as constraints (such as grid voltage/loading and DG on/off time).
- The *environmental aspect* corresponds mainly to GHG emission from DG.

(Hatziargyriou, 2014)

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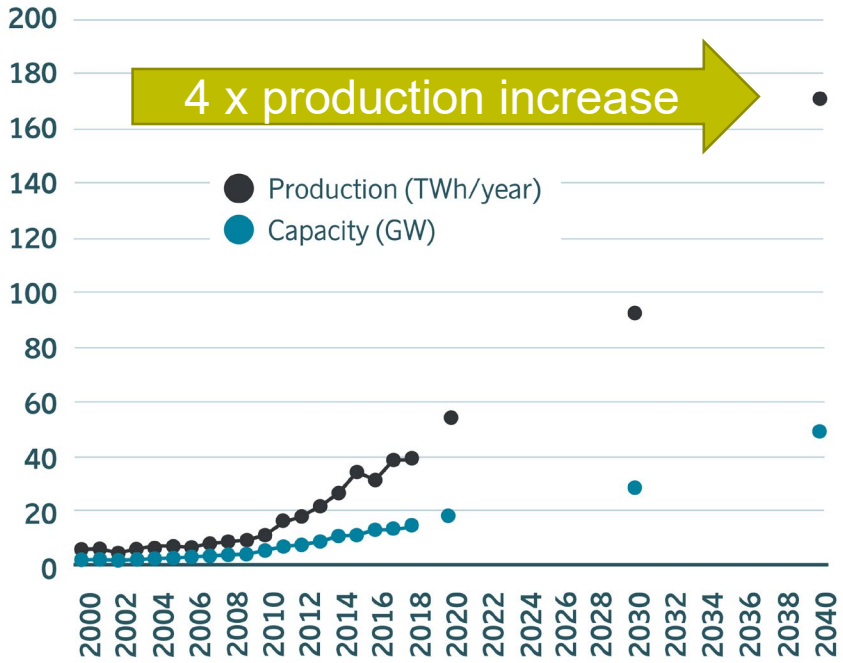
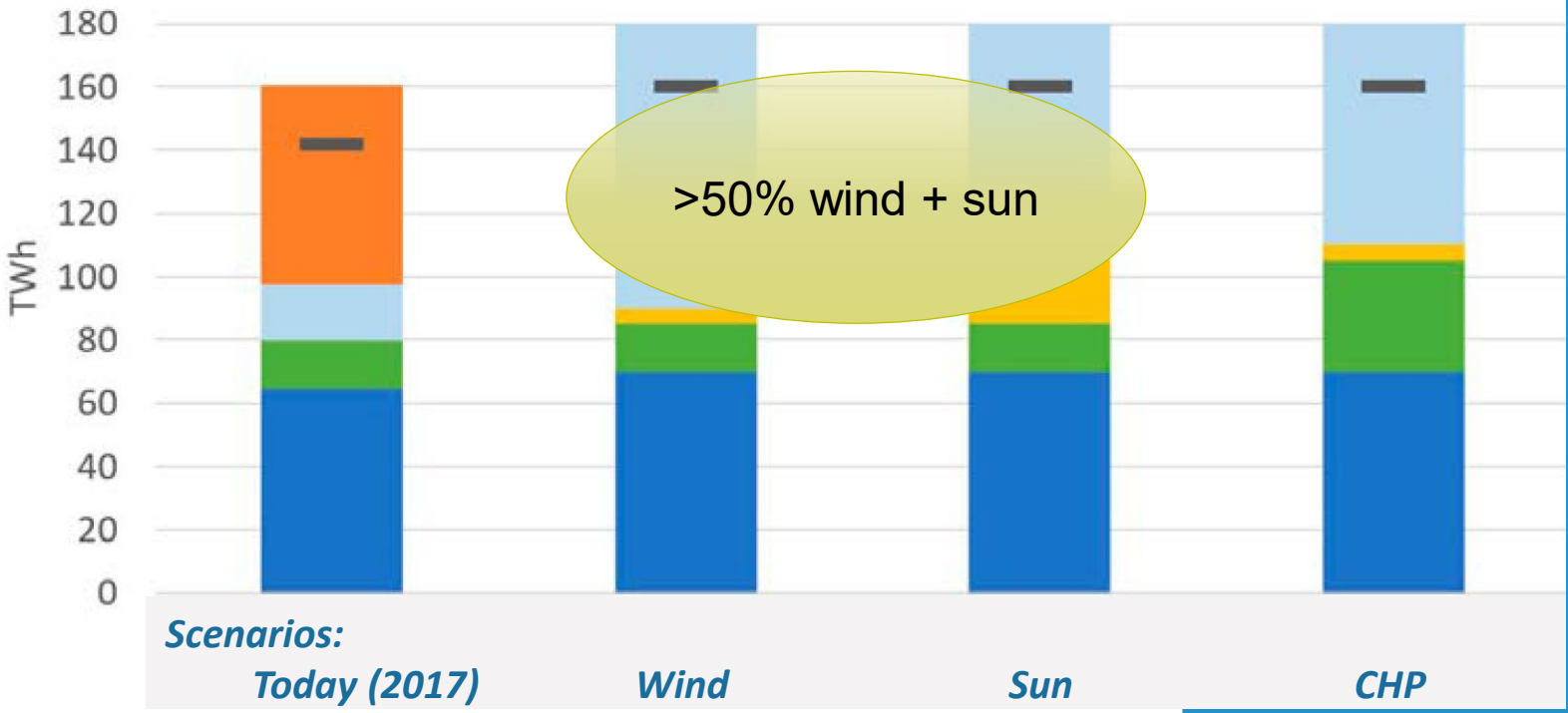
Future Grids

- Windpower in the Nordics



(Nordic TSOs 2019)

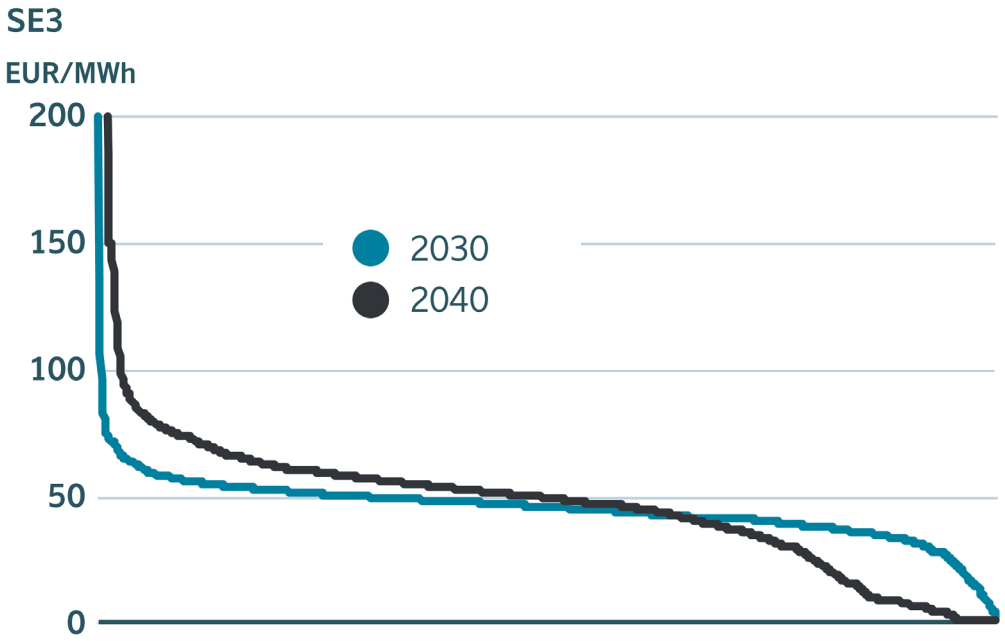
- Generation mix in Sweden 2040



(STEM 2019)

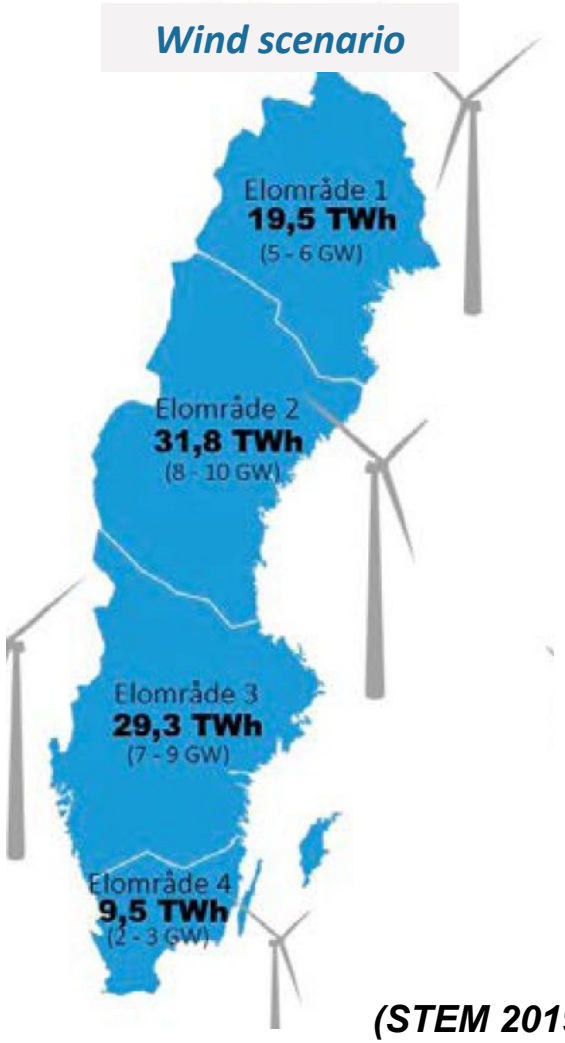
Future Grids

- Price duration curves “SE3”



(Nordic TSOs 2019)

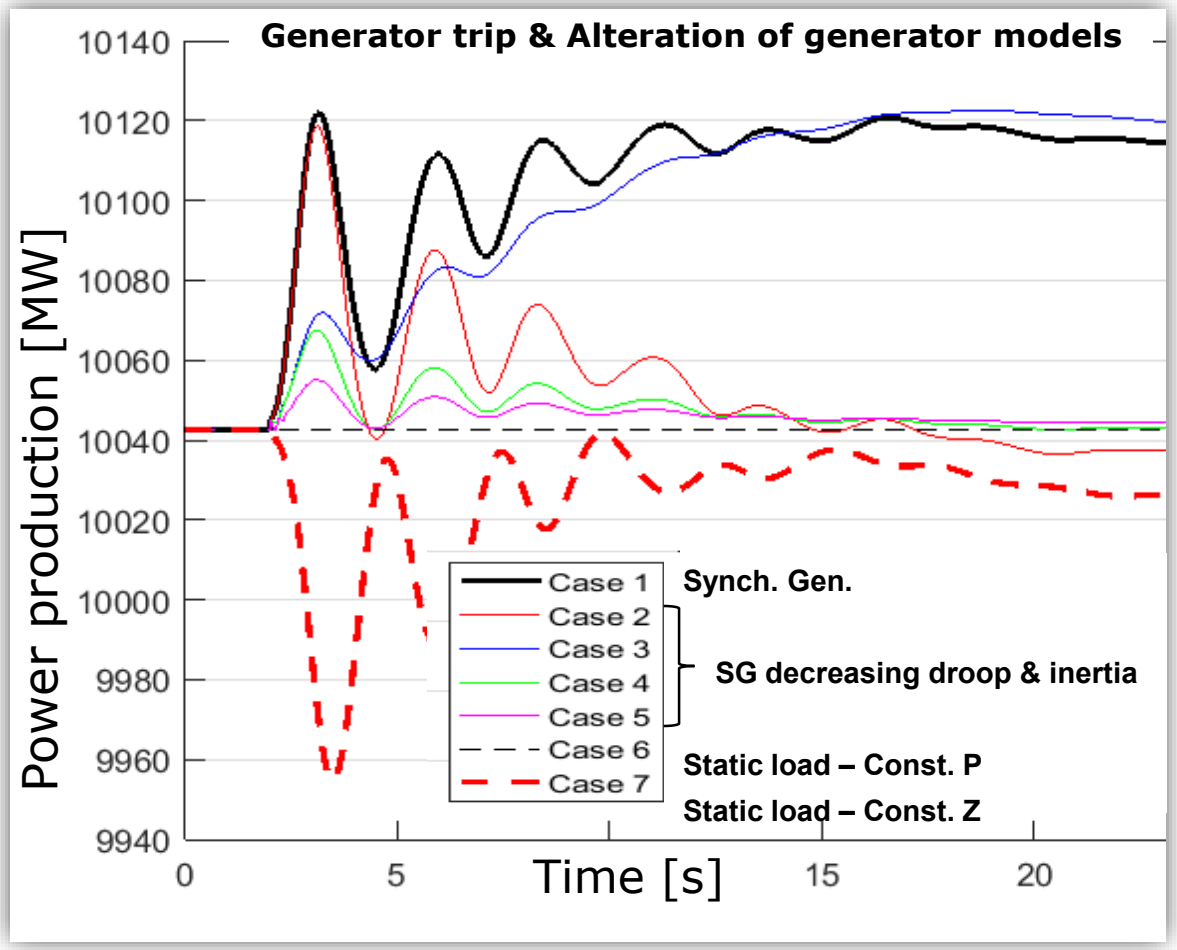
- Geographical placement of wind power



(STEM 2019)

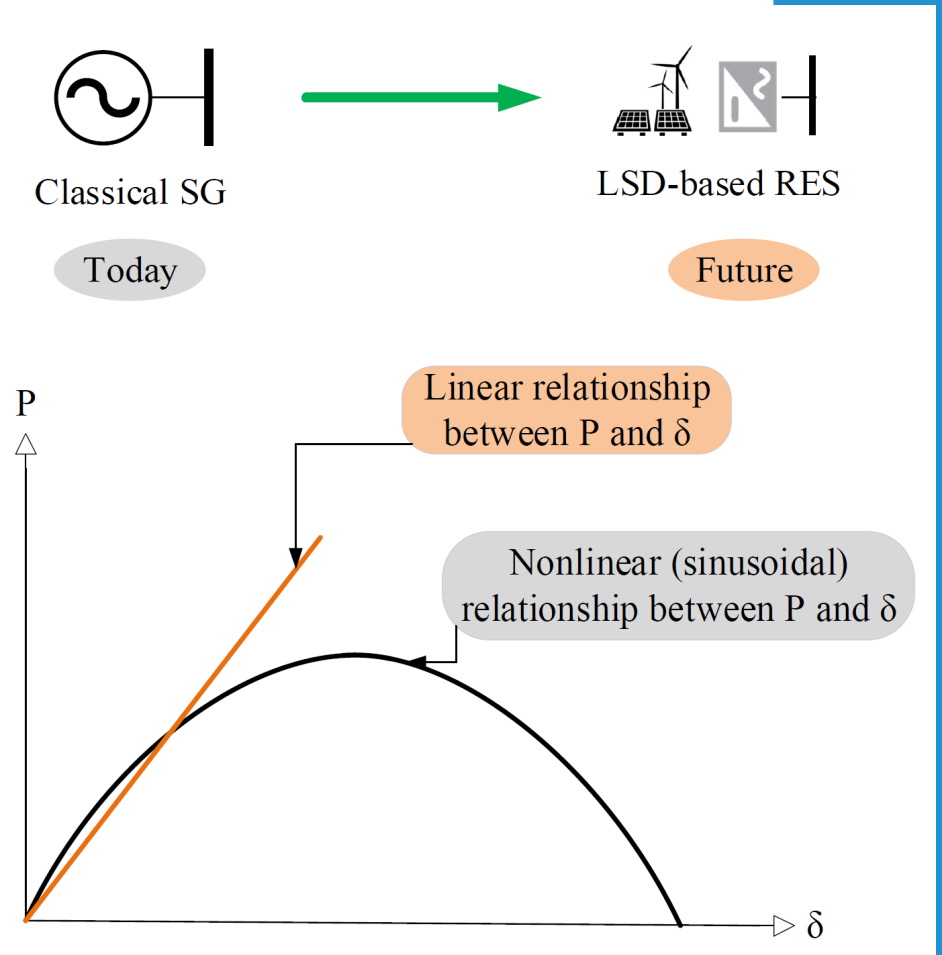
Future Grids

- Towards 100% PEID…



(Hillberg, 2017)

- LSD is the future…

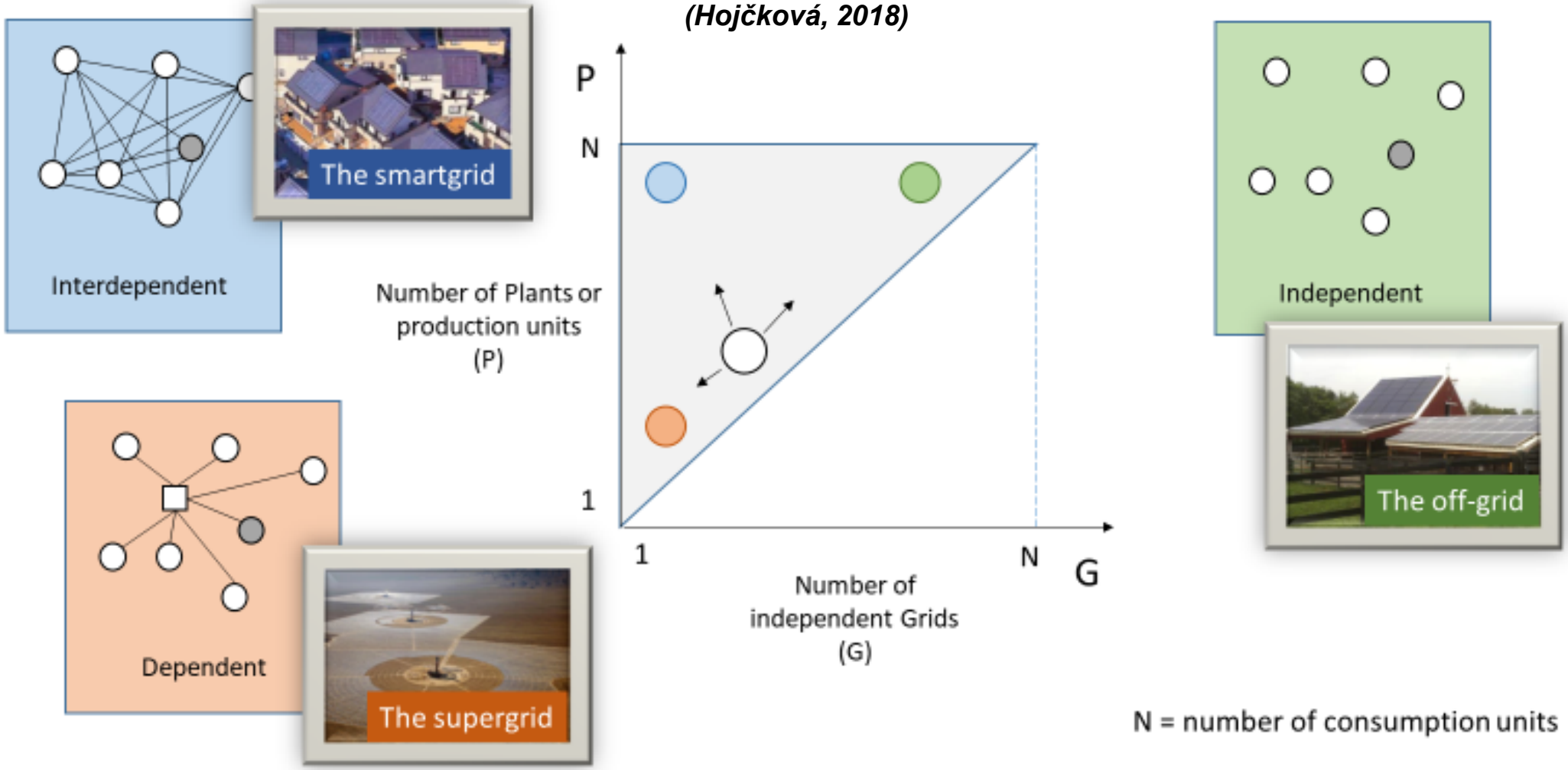


(RESERVE, 2018)

Future Grids

Three electricity futures

(Hojčková, 2018)



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Summary

Two trends largely influencing the evolution process of the power grids:

- Large-scale, system or intra-system solutions - *the MEGA grid perspective*
- Small-scale, local or regional solutions – *the micro grid perspective*

How do these trends influence each other?

- Does one trend outcompete the other?
- Does increased ***micro grid*** investments increase the need for ***MEGA grid*** investments, and vice versa?
- To what extent can ***micro grids*** benefit from ***MEGA grid*** solutions, and vice versa?

Call for participation

New ISGAN Annex 6 activity:

iea-isgan.org/micro-vs-mega-grids/

Goal:

Provide insights of considering **both micro and MEGA grid perspectives** in the decision-making process for the sustainable development of the power grids

Next steps:

Workshop in **Montreux October 2nd**

Development of report and scientific publications during autumn 2019

For interest to participate, contact:

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Acknowledgement

This work is prepared if the framework of

ISGAN Annex 6: Power Transmission & Distribution Systems
Promoting solutions to enable power grids to maintain and improve security, reliability and quality of electric power supply

iea-isgan.org/our-work/annex-6/

ISGAN is an initiative of the Clean Energy Ministerial and an IEA Technology Collaboration Program.
The vision of ISGAN is to accelerate progress on key aspects of smart grid policy, technology, and investment

Further reading

- FED: Fossil Free Energy Districts; www.uia-initiative.eu/en/uia-cities/gothenburg
- Hatziargyriou 2014: *Microgrids: Architectures and Control*; Ed. Hatziargyriou; Wiley, 2014
- Hillberg 2017: *Analysis of dynamic aspects of the Continental European power system*; Hillberg, Lindahl, Pinares, Segundo Sevilla, Korba, Uhlen, Sattinger; CIGRE Symposium Dublin 2017
- Hojčková 2018: *Three electricity futures: Monitoring the emergence of alternative system architectures*; Hojčková, Sandén, Ahlborg; Futures 98, 2018
- Nordic TSOs 2019: *Nordic Grid Development Plan 2019*
- RESERVE 2018: *Linear Swing Dynamics Validation and Application in Future Converter-Based Power Systems*; Musa, Monti, Toma, Milano, Manjavacas, Mazza, Arrigo, Bompard; RESERVE D2.3, 2018
- SIMRIS: *INTERFLEX E.ON Demo "Simris"*, www.eon.se/om-e-on/innovation/lokala-energisystem/direkt-fran-simris.html
- STEM 2019: *100% förnybar el*; Swedish Energy Agency

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