FUTURE ELECTRICITY GRIDS IN ENERGY ISLANDS – A SCENARIO ANALYSIS WITH CYBER SECURITY IMPLICATIONS

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Background

- Energy islands, geographically limited micro-grids, are being developed as a tool for electricity redundancy and resilience.
- During the first 20 years of the 21st century, the rationale has been accidents and natural disasters. During the last few years, preparation for hostile actions has been the main driving force.
- In a project funded by the Swedish Energy Agency, we are conducting theoretical, simulation and practical studies of energy islands, including a small city for case studies.

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Research questions

- What are the main drivers, and uncertainties for the future development of energy islands?
  - Are there distinct plausible future scenarios?
- What effect will this development have on cyber security vulnerabilities?
  - Can this be modelled or simulated?

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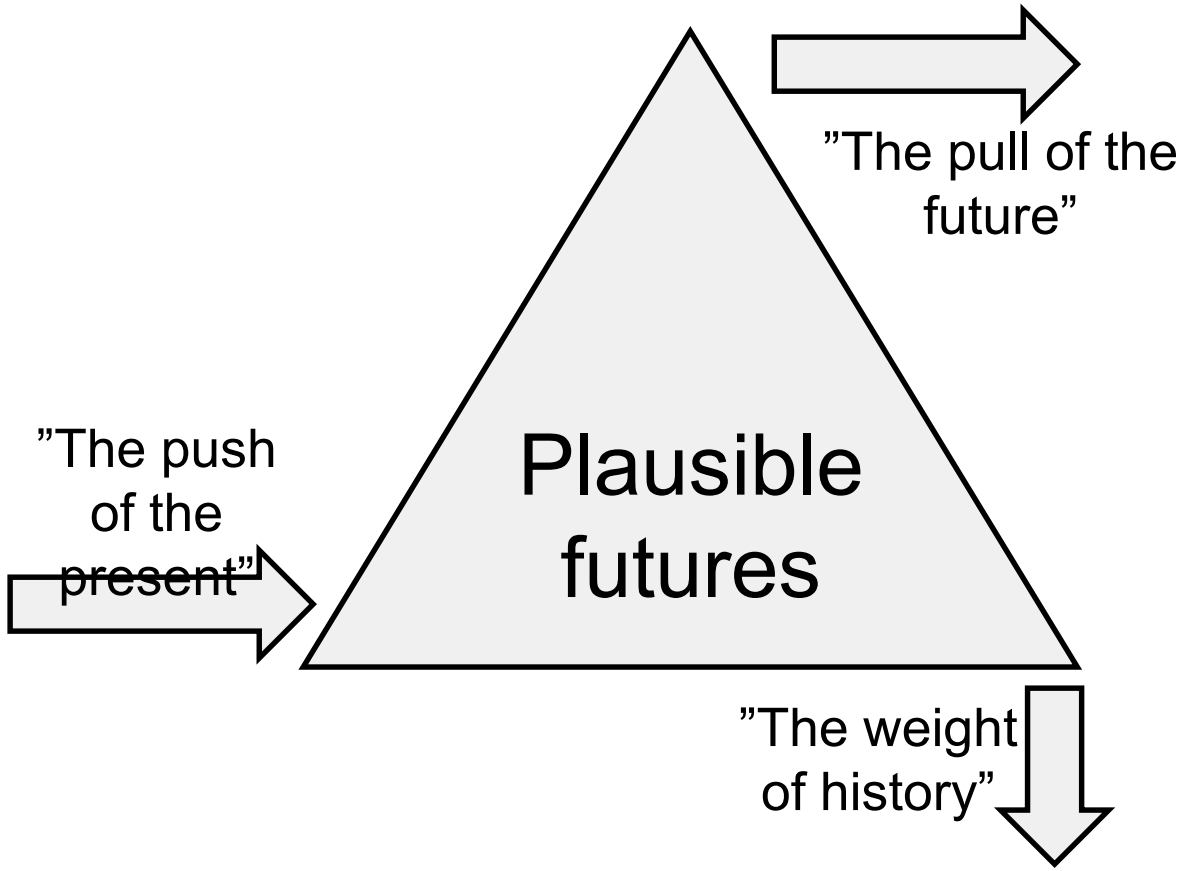
Methodology

- Multidisciplinary expert foresight workshops
  - Grid experts
  - Renewable energy researchers
  - Energy policy researchers
  - Societal resilience experts
- Scenario analysis based on the main uncertainties:
  - *inclusion of intermittent renewable energy sources*
  - *implementation of smart demand-side control systems*.

The ”futures triangle”



Based on Sohail Inayatullah

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Initial findings

- Energy islands will not be developed separately from the regular grid, but as augmentation to it, unless explicit decisions are made.
  - Due to cost, synergies and grid investments in redundancy
  - **Implication**: What happens in the regular grid is also valid for the energy island

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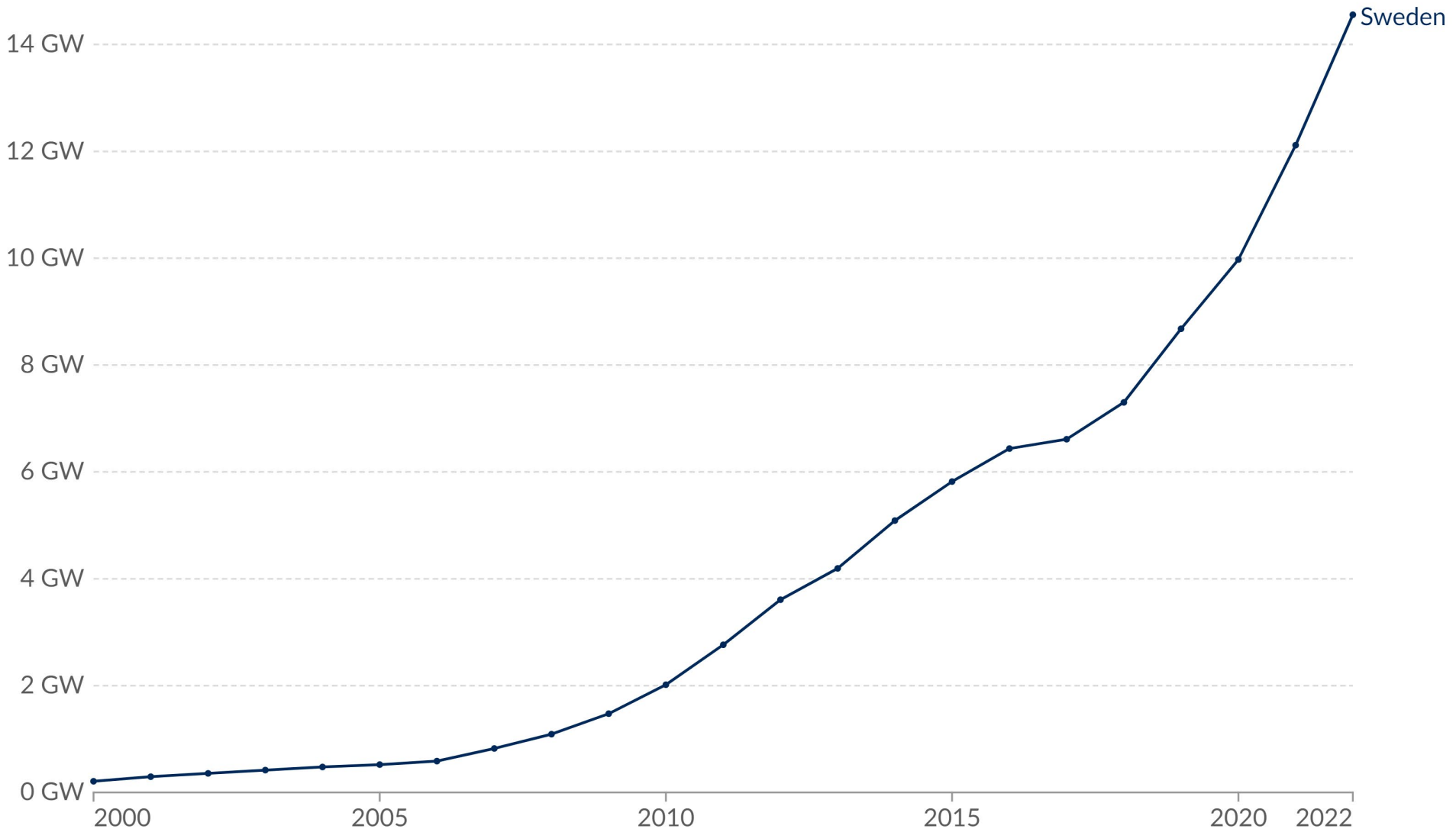
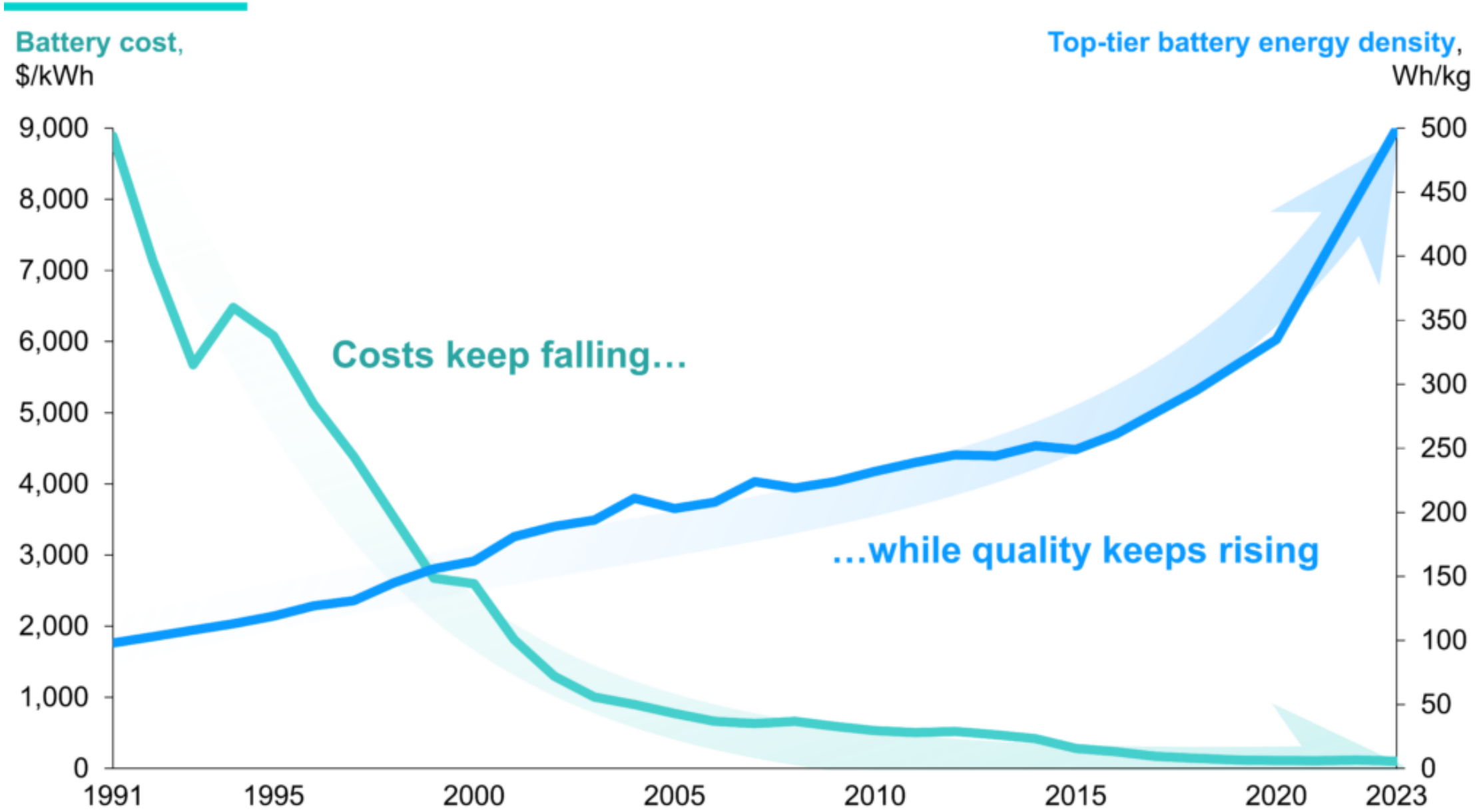
Installed wind energy capacity

Cumulative installed wind energy capacity including both onshore and offshore wind sources, measured in gigawatts (GW).

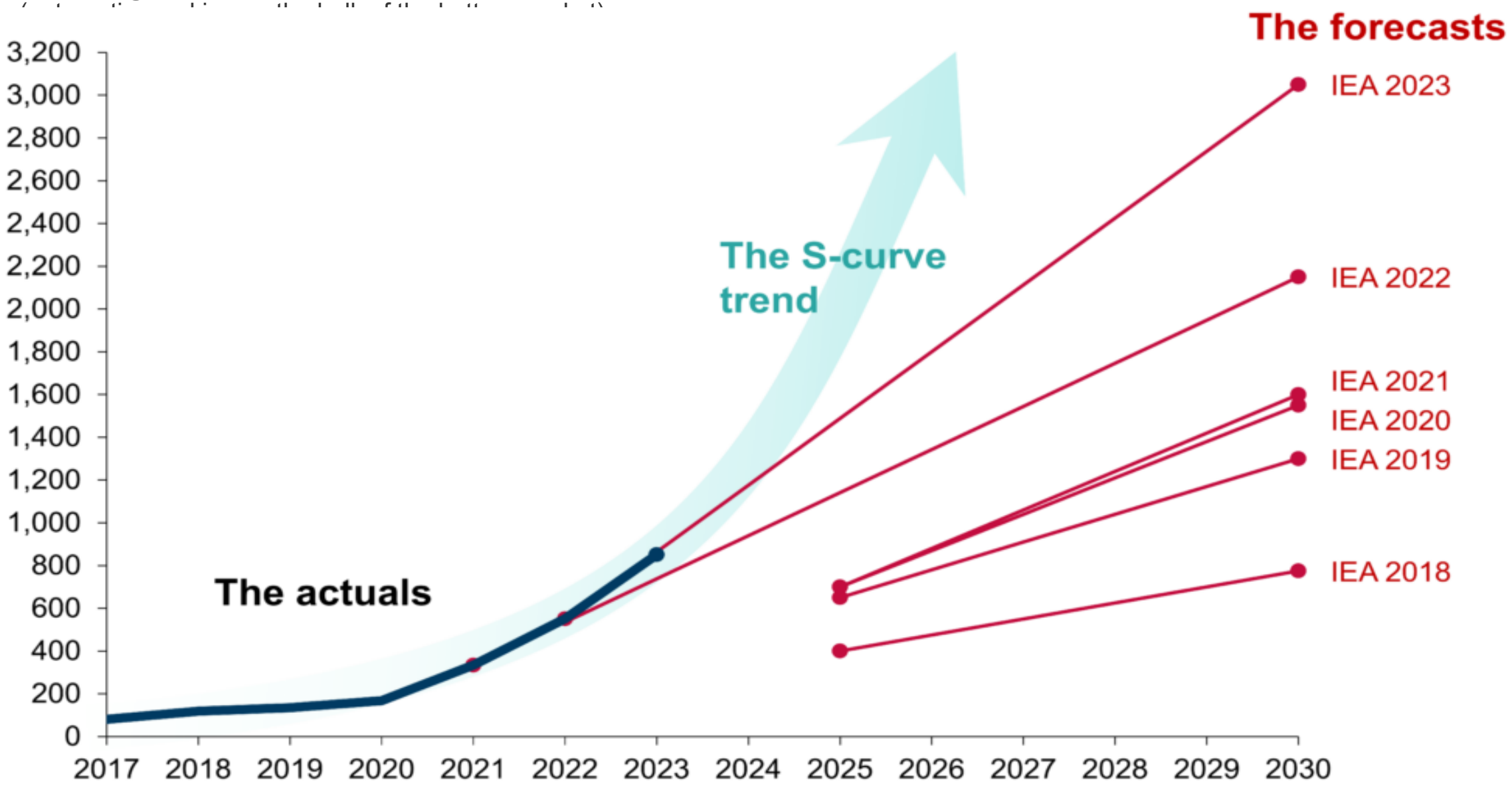


Data source: International Renewable Energy Agency (2023)

OurWorldinData.org/renewable-energy | CC BY


Battery cost,
$/kWh
Top-tier battery energy density,
Wh/kg
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
500
450
400
350
300
250
200
150
100
50
0
1991
1995
2000
2005
2010
2015
2020
2023
Costs keep falling…
…while quality keeps rising

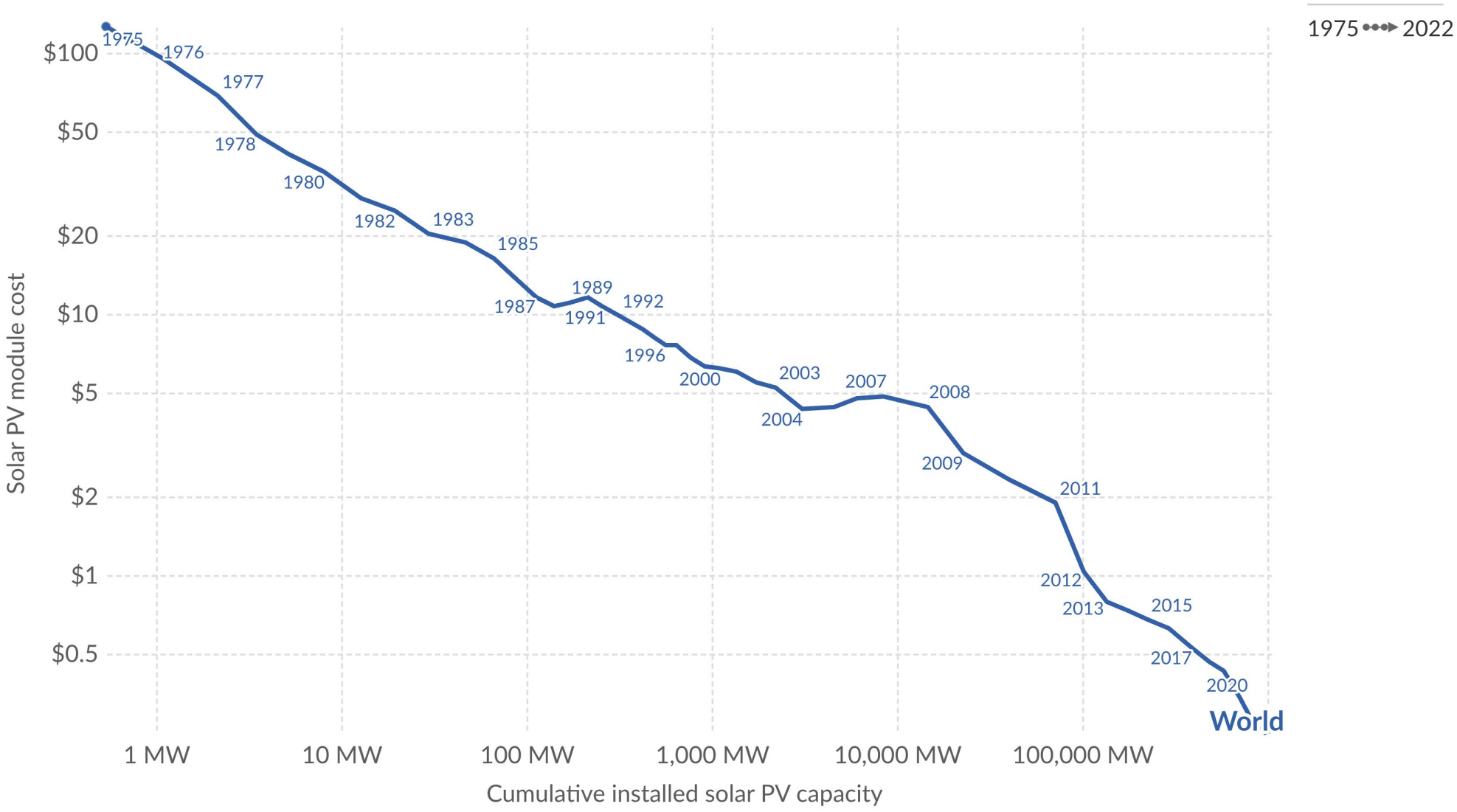
Automotive lithium-ion battery demand, IEA forecast vs. actuals, GWh/y



Solar panel costs have fallen by around 20% for every doubling of global cumualtive capacity

Costs are measured in US dollars per Watt, adjusted for inflation.

Our World in Data



Data source: IRENA (2023); Nemet (2009); Farmer and Lafond (2016)

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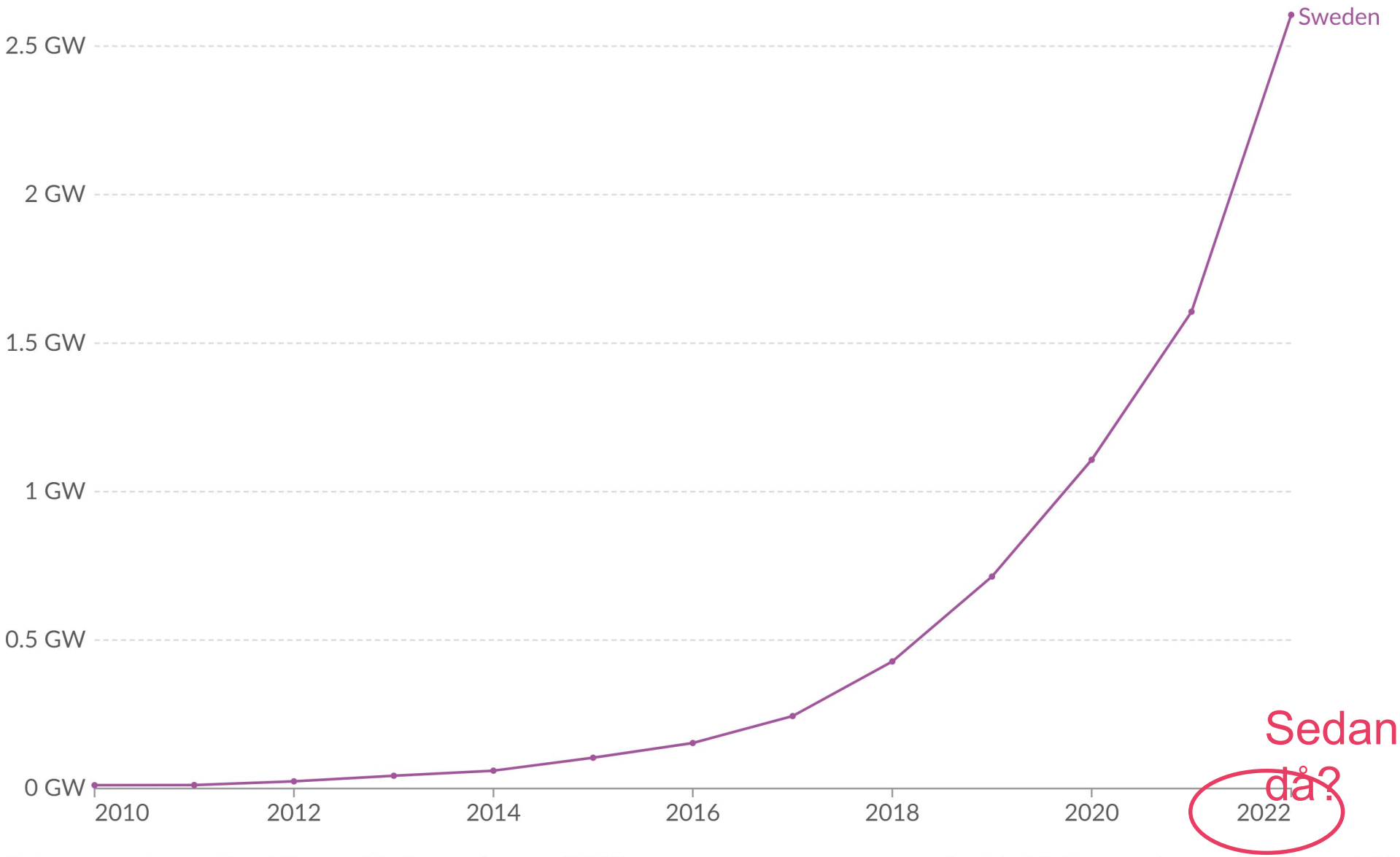

Sedan dess då?

Data source: International Renewable Energy Agency (2023)

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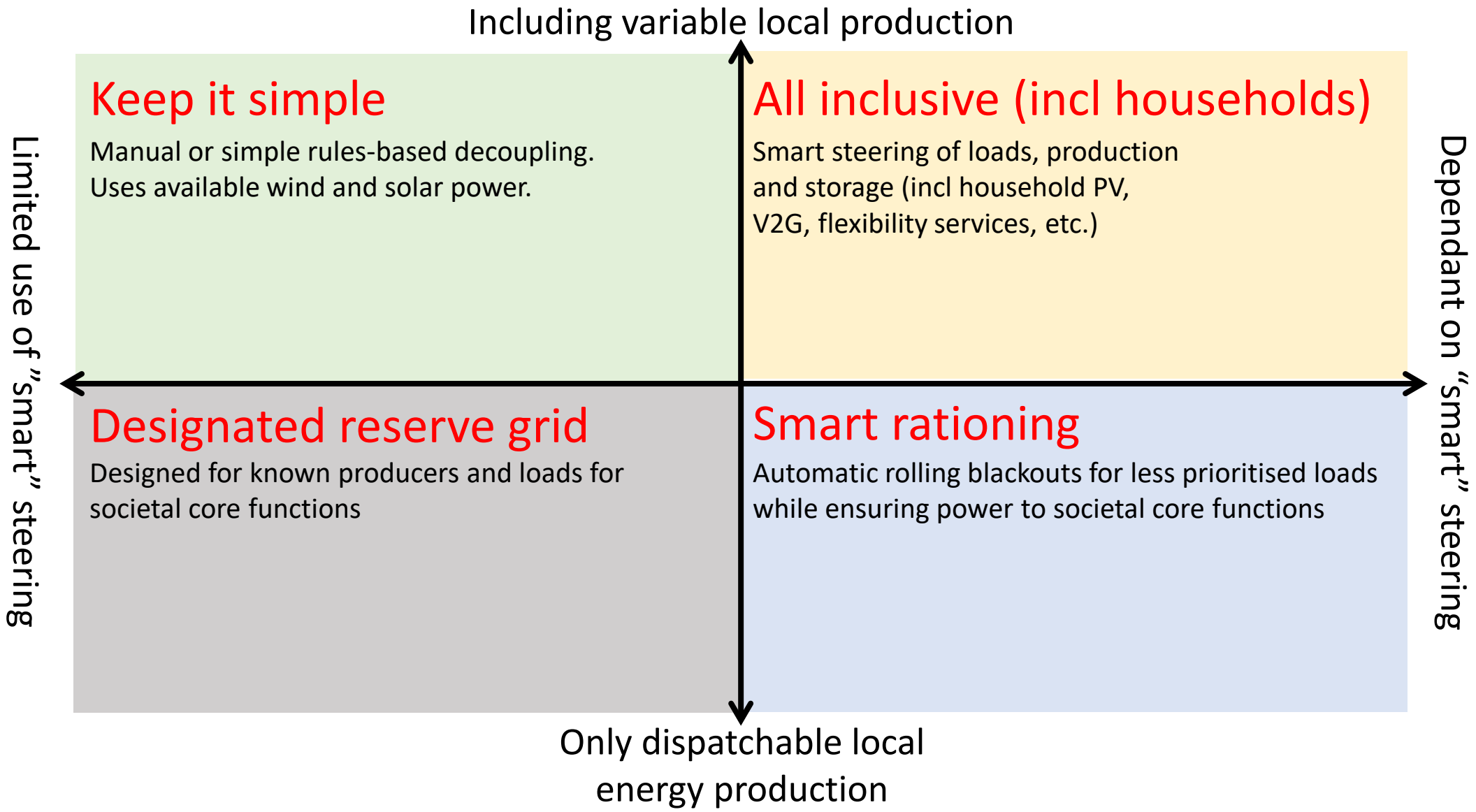
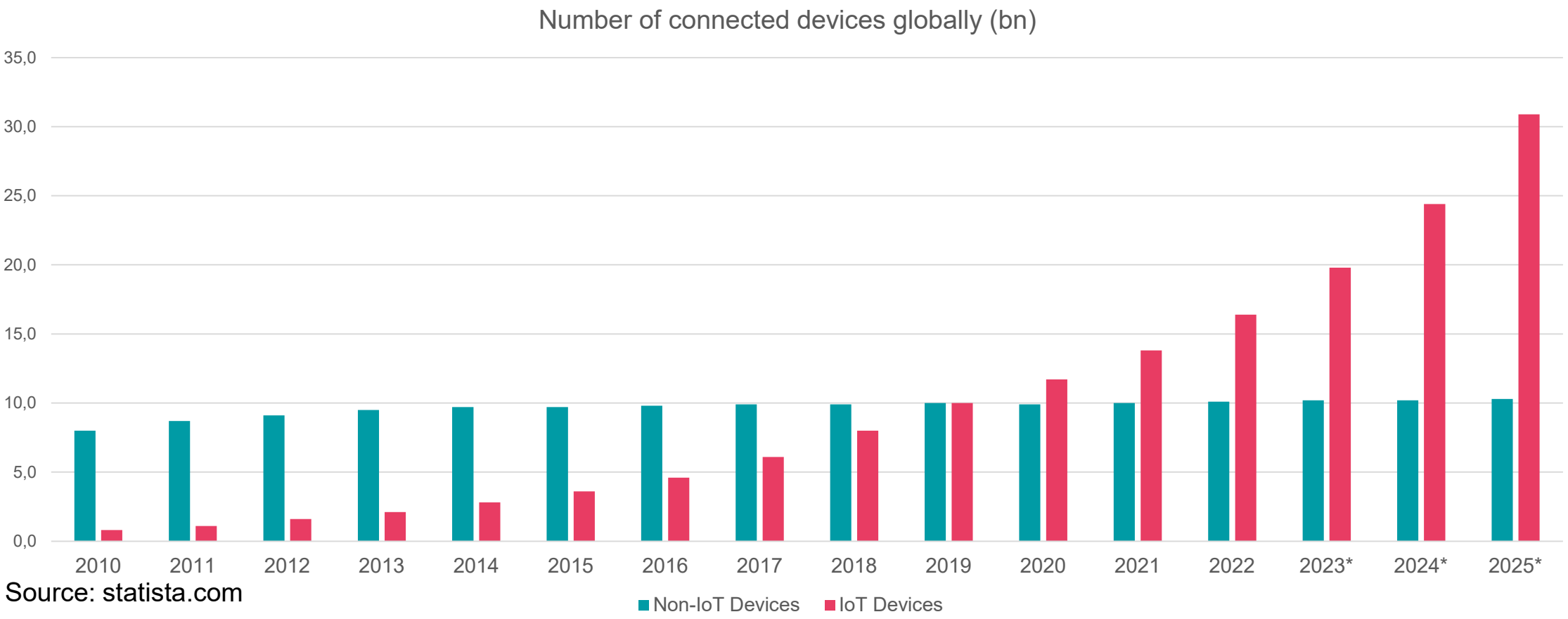
Scenario cross – future electricity grid in energy islands

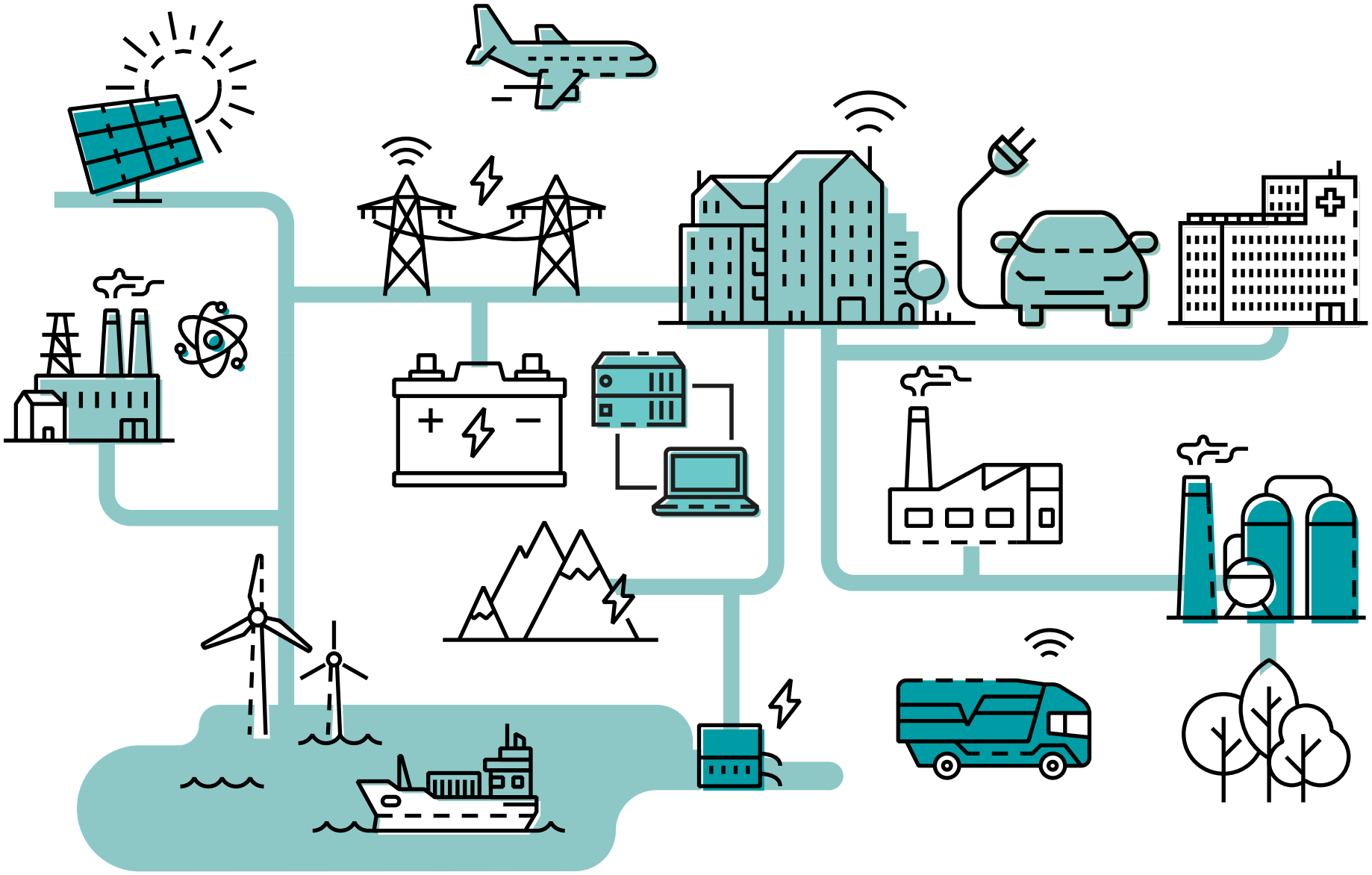


Hur många uppkopplade enheter finns det?

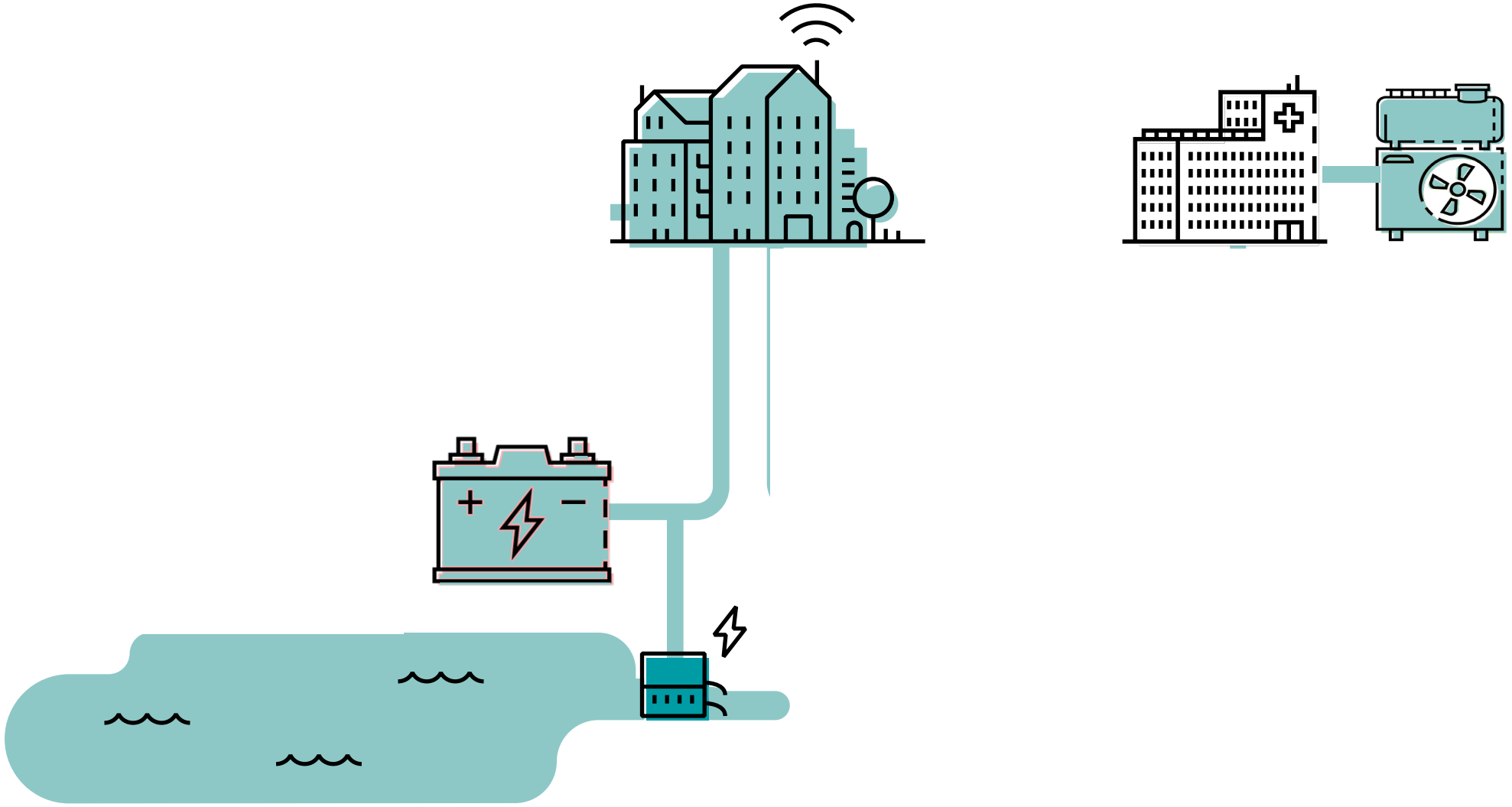


Source: statista.com

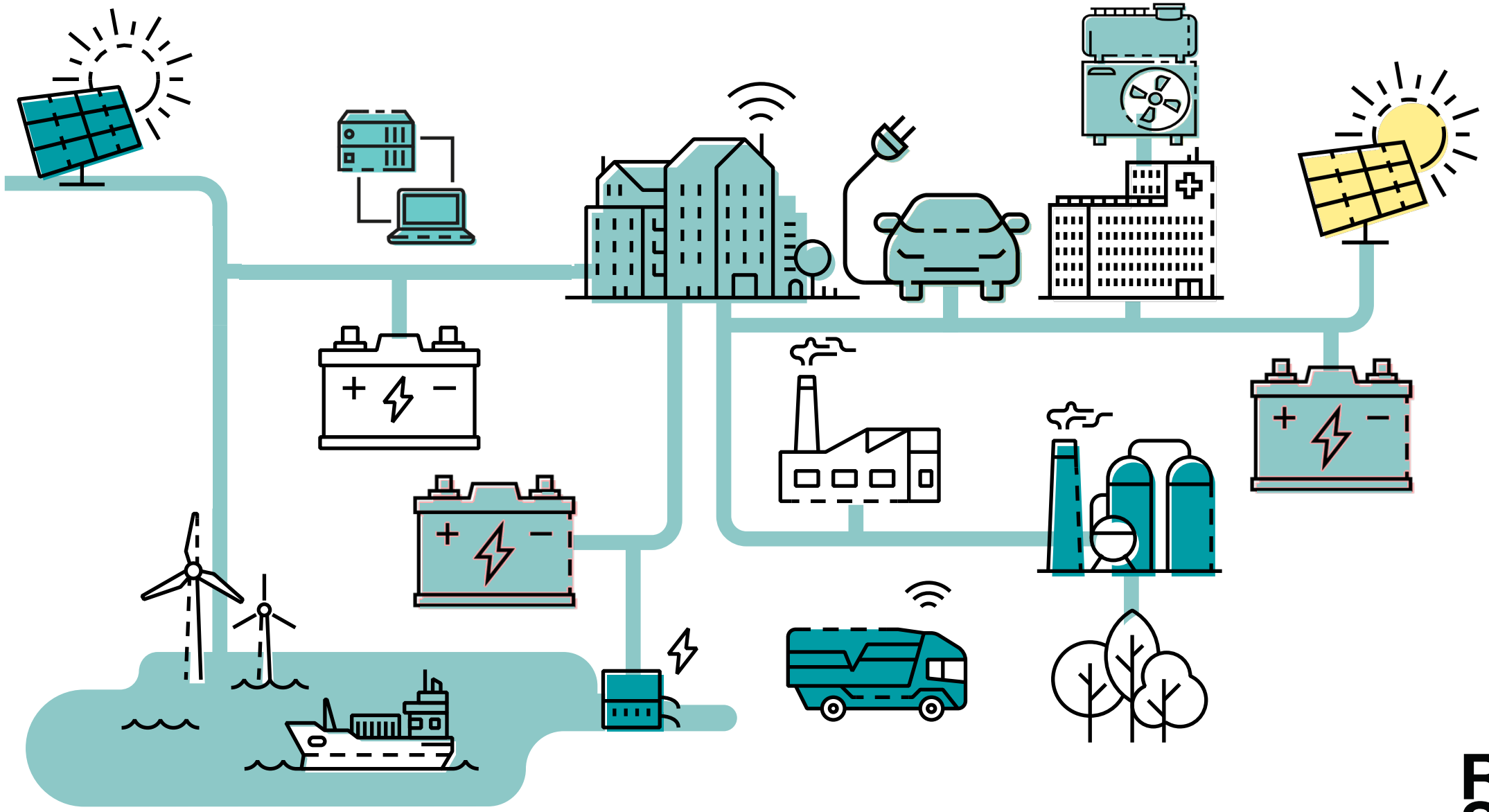
Concept of the electricity grid of the future (today?)



Concept of the electricity grid energy islands today



Concept of the electricity grid of the future in energy islands



Scenario cross – future electricity grid in e

Including variable

Limited use of "

chable local
roduction

"smart" steering

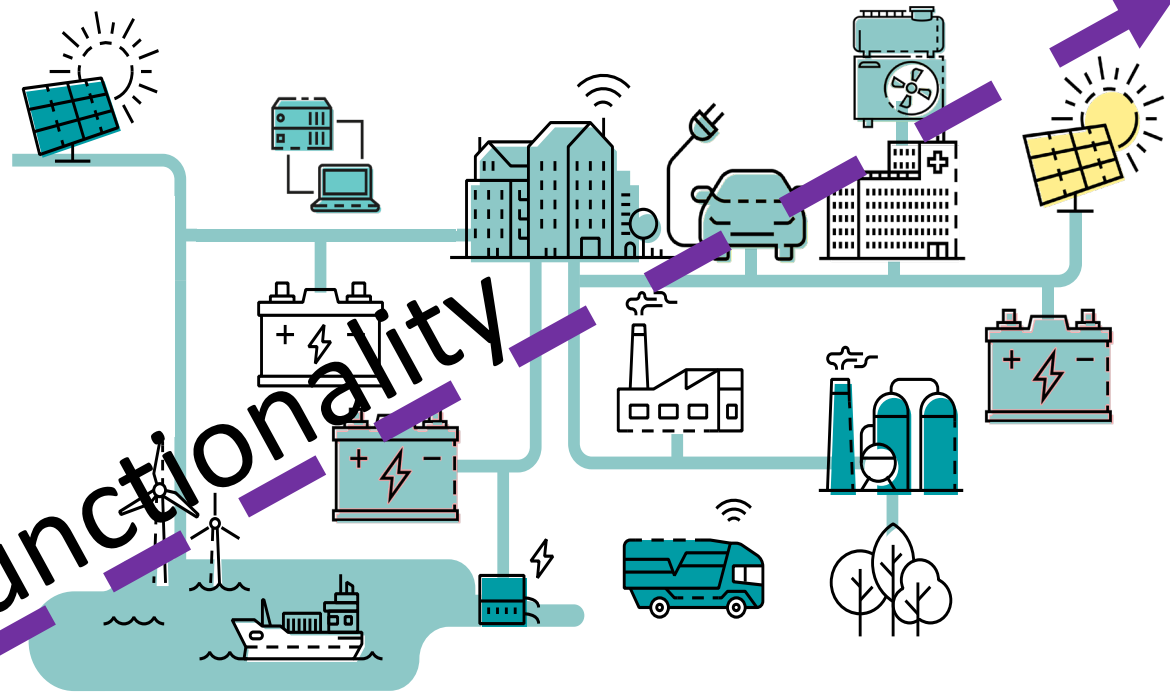
Keep it simple

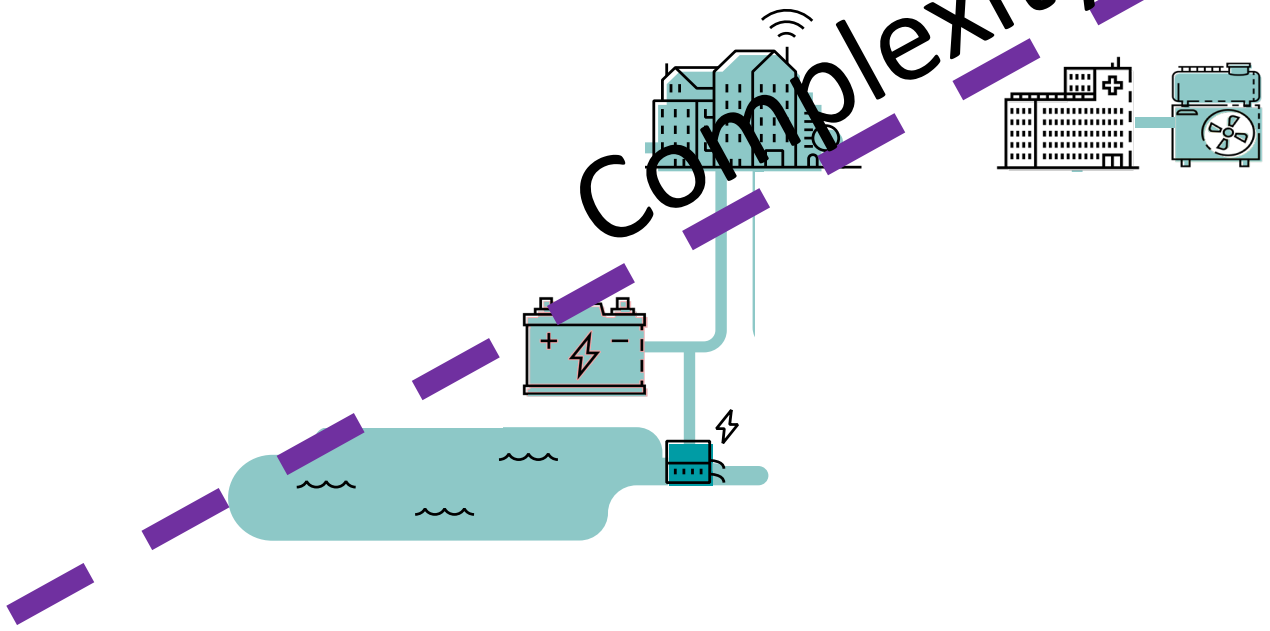
Manual or simple rules-based decoupling.
Uses available wind and solar power.

Smart rationing

Automatic rolling blackouts for less prioritised loads while ensuring power to societal core functions

Complexity and functionality





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Initial findings, con’t

- Energy islands will not be developed separately from the regular grid, but as augmentation to it, unless explicit decisions are made.
  - Due to cost, synergies and grid investments in redundancy
  - **Implication**: What happens in the regular grid is also valid for the energy island
- Tomorrow’s energy islands will be dependent of smart control systems, connected to networks.
  - Due to functionality, cost and efficiency
  - **Implication:** All major loads (and production units) will be possible to remote control. In theory also by malign actors.
  - **Bonus:** Also in reality!

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Q&A

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