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# How to manage the changing electricity system

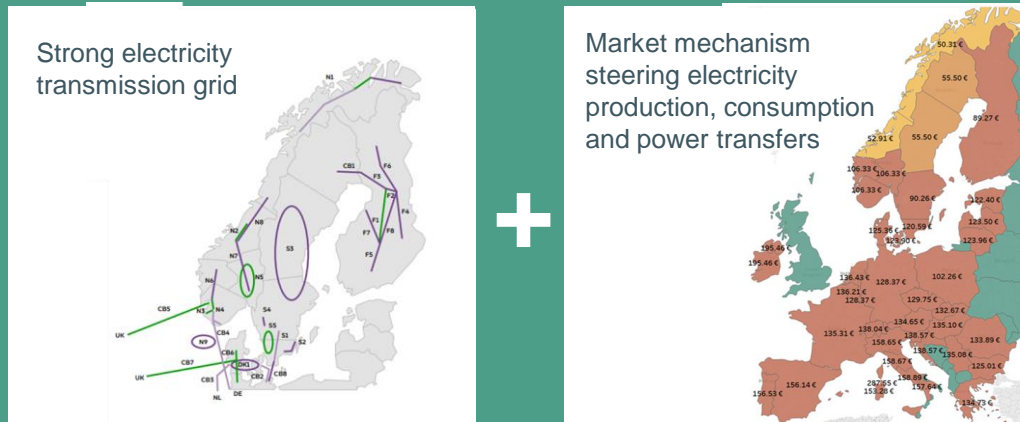
Aalto Energy Forum

**FINGRID**

# Fingrid as a company

# The tasks of Transmission System Operators

## The platform for the electricity market



- Connecting customers and transmitting electricity between the connection points
- Developing the power transmission grid
- Promoting the electricity market:
  - Giving the transmission capacity for the market to use
  - Developing the market places and rules
  - Sharing information to market players
- Operating the power system and keeping it secure in all situations

## Co-operation across the borders:



# Fingrid's mission and vision

## MEGATRENDS



Climate change and transformation of the energy system



Security of energy supply and dependency on electricity



Globalisation and responsibility



Digitalisation



## OUR PROMISES

We will promote Finland's competitiveness by supporting the investments needed for electrification

- We will build and maintain a reliable power grid
- We will develop the established operating standards in the market and ensure a single price area in Finland

## OUR VISION



We are a forerunner for electricity network operations and we are respected and influential in energy matters.



## OUR MISSION

We will cost-effectively secure reliable electricity for our customers and society, and we will shape the clean, market-oriented energy system of the future

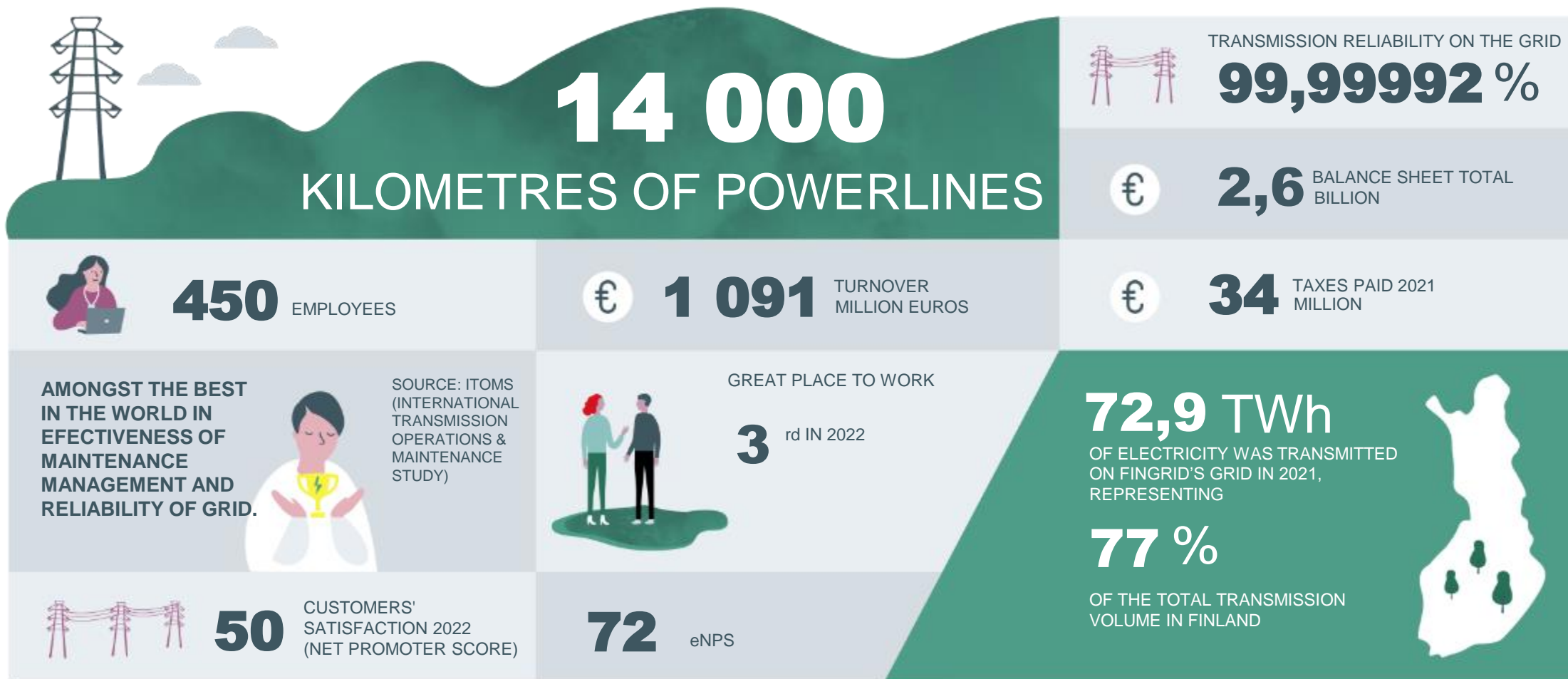


## OUR VALUES

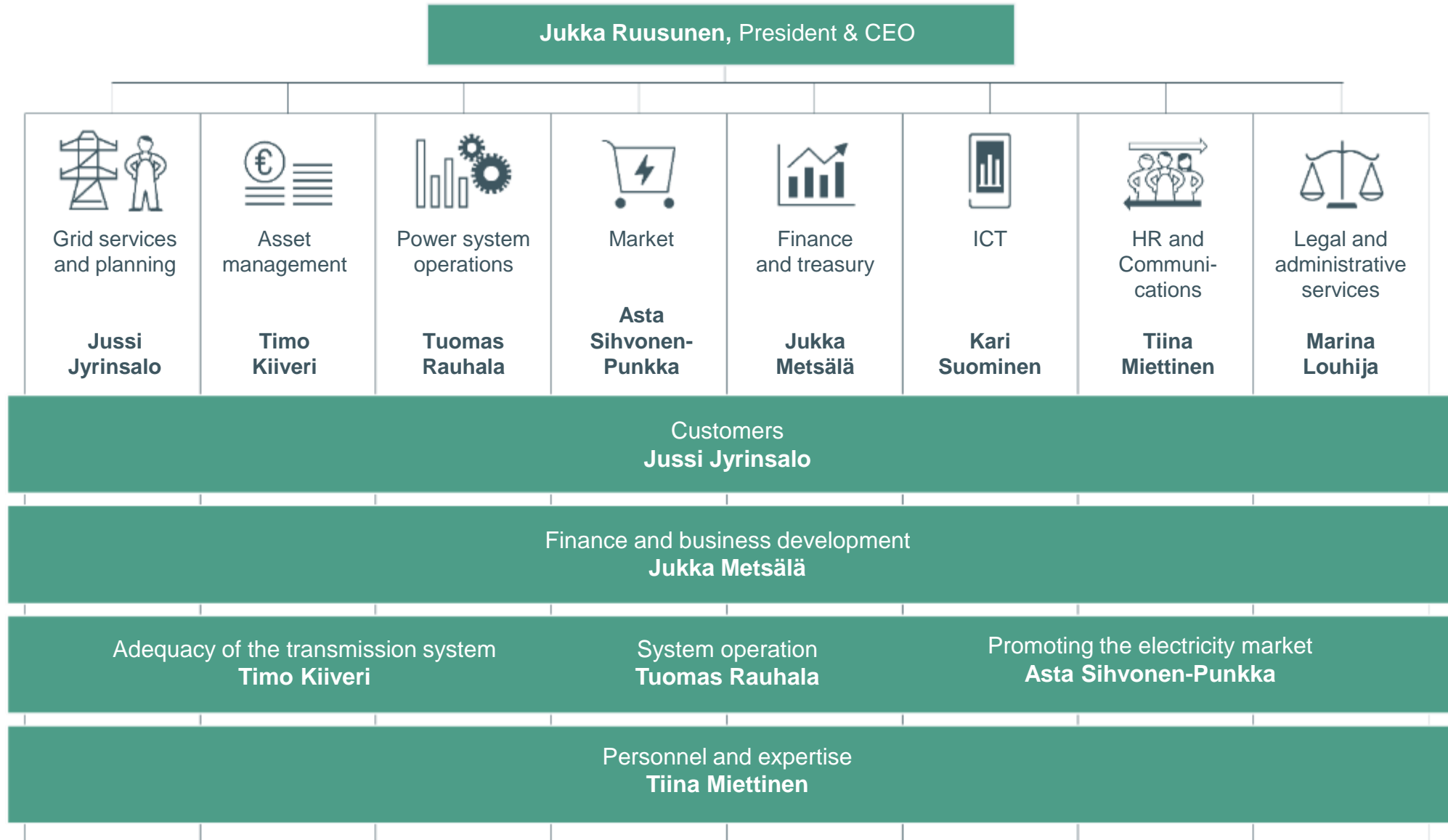
- Transparent
- Efficient
- Fair
- Responsible

TOWARDS A CARBON-NEUTRAL FINLAND IN 2035

# Fingrid's main figures



# Fingrid's organization

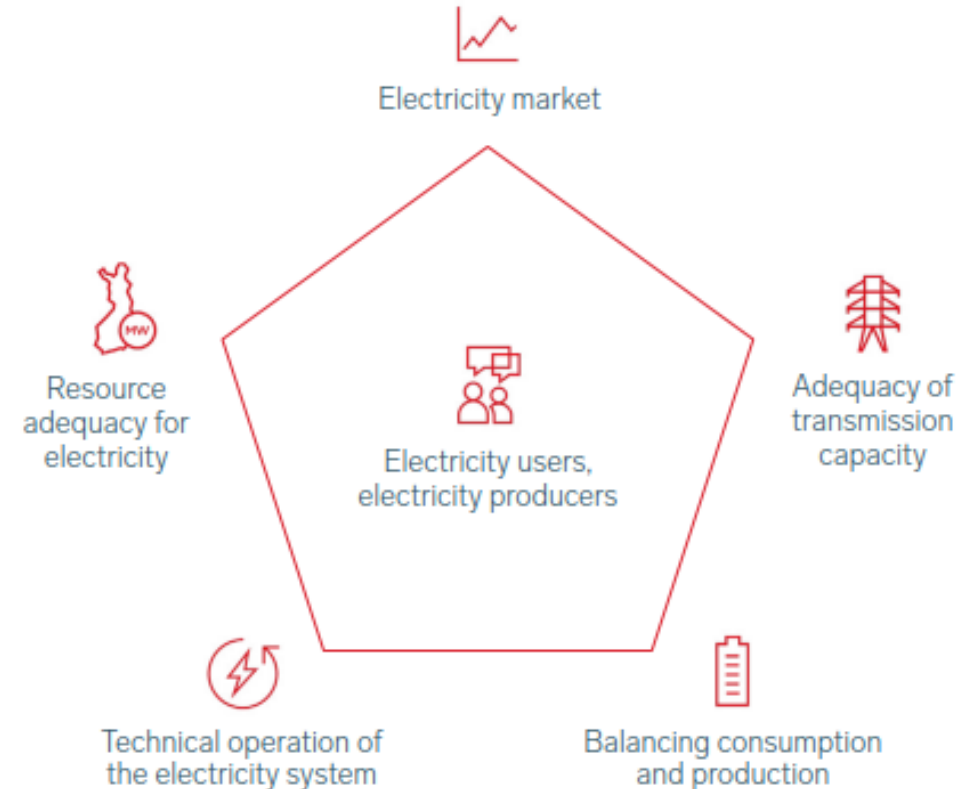


# The changing system

# The system changes create challenges

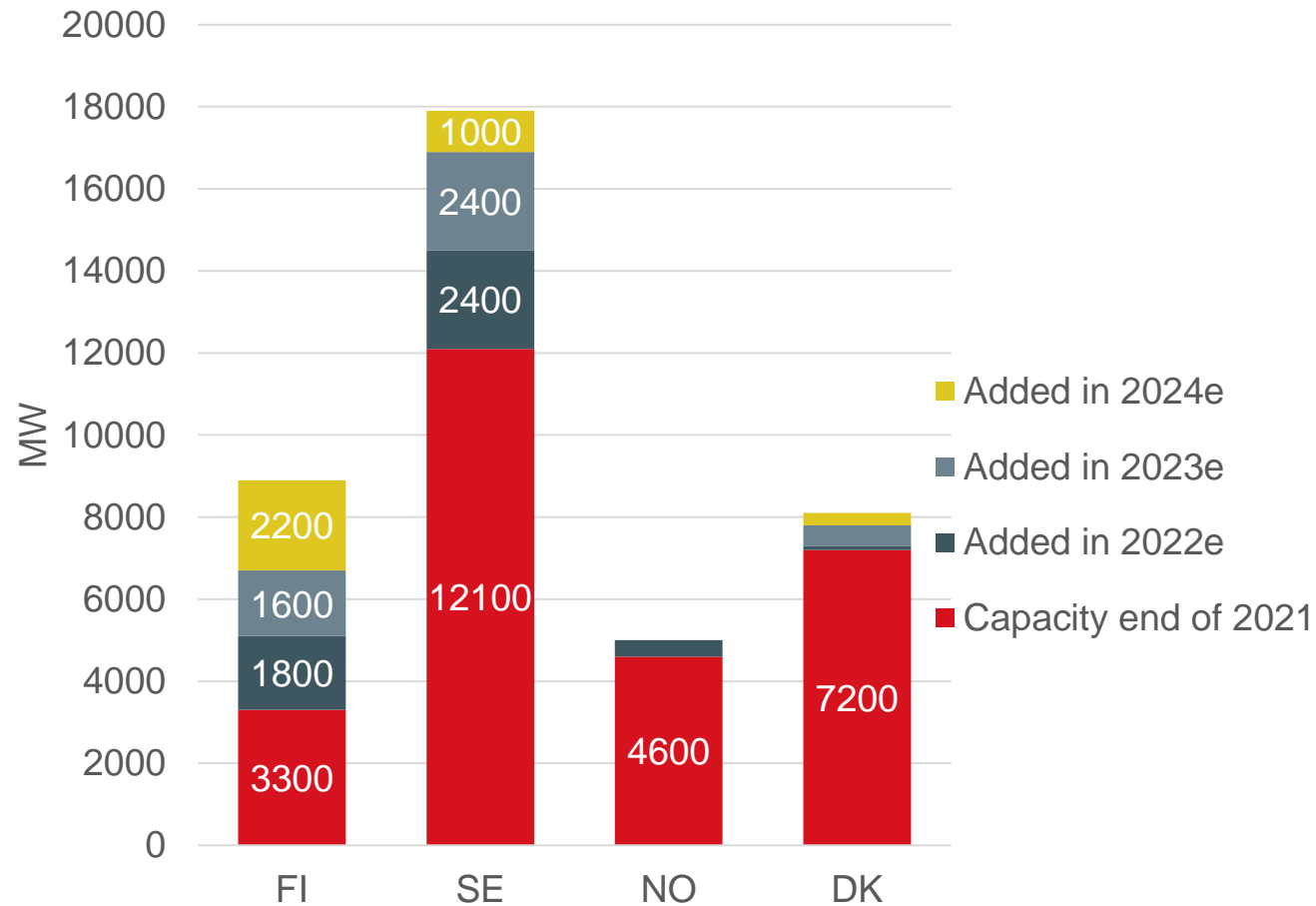
Most of the electricity production is becoming converter connected and will vary according to the weather (wind and solar):

- Technical characteristics of the electricity system will change
- It will be harder to control the frequency and the voltage of the grid
- It will be harder to match the production with the consumption (adequacy and flexibility)
- The fluctuation of market prices will increase
- The transmission capacity of the grid will be challenged.



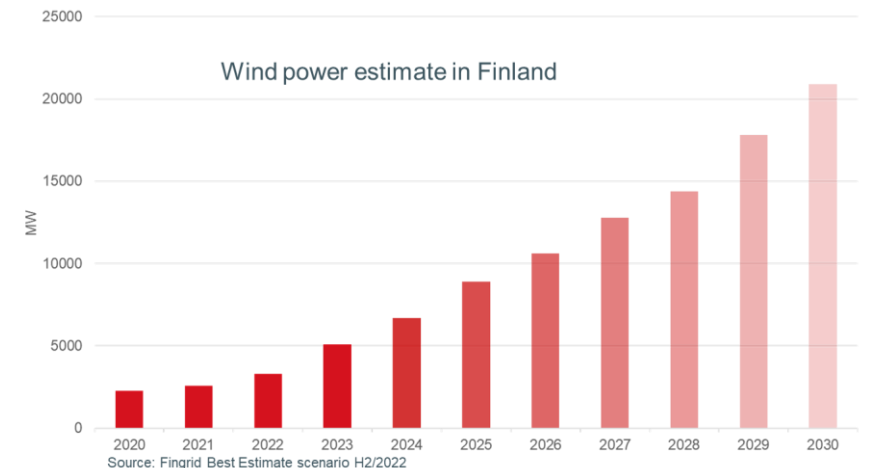


# Rapid wind power expansion in the Nordic system



Data: Fingrid, SWEA, ENS.dk

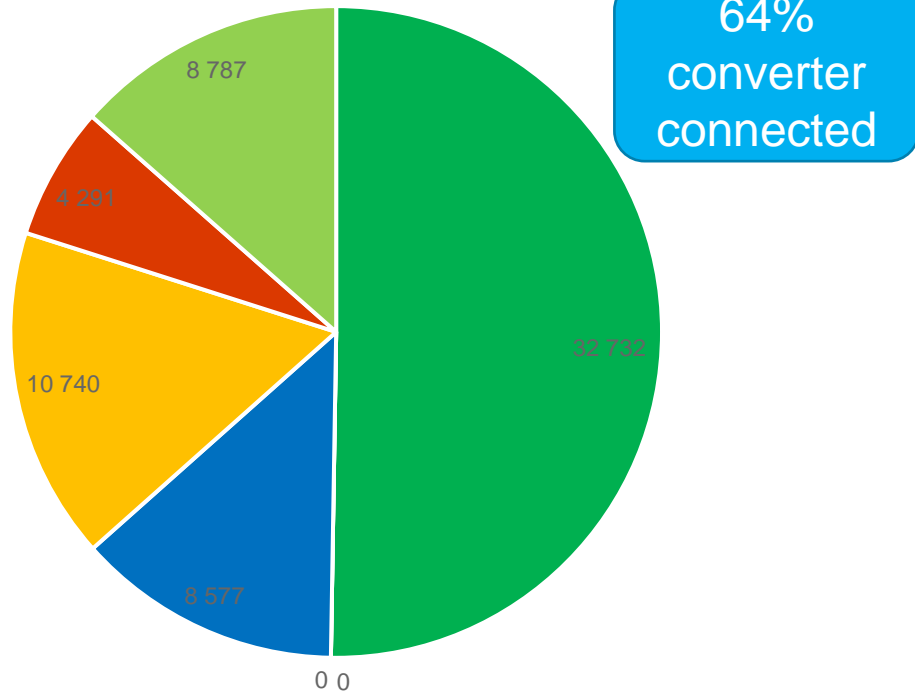
- Nordic wind to increase from 27 GW to 40 GW by the end of 2024
- So far mainly onshore wind projects but big offshore projects under planning
- Capacity to be added especially in Sweden and in Finland (we have 165 GW of connection enquiries!)



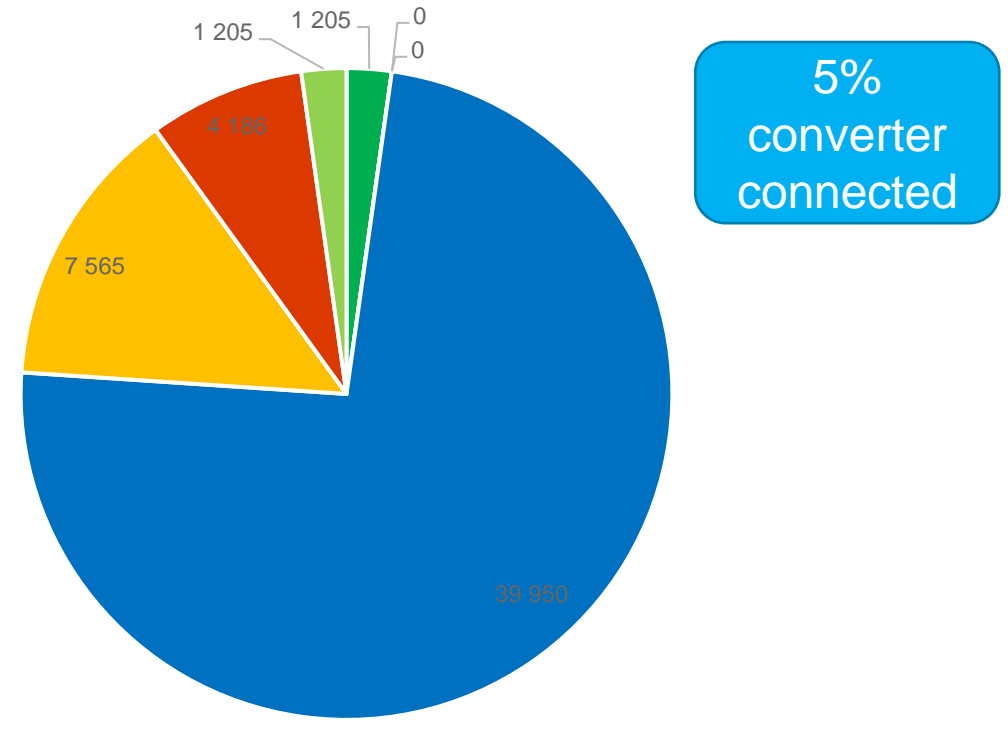
Source: Fingrid Best Estimate scenario H2/2022

# The generation mix will vary by the hour

Nordic generation mix in year 2027 on hour 366



Nordic generation mix in year 2027 on hour 237



■ Wind ■ Solar ■ Battery ■ Hydro ■ Nuclear ■ Other thermal ■ HVDC import

■ Wind ■ Solar ■ Battery ■ Hydro ■ Nuclear ■ Other thermal ■ HVDC import

# Transition to a converter dominated system



Source: <http://electrical-engineering-portal.com>

From synchronous generators to converter-based resources

Reduced inertia, short circuit power and access to reserves

Increased vulnerability against disturbances



Source: <http://media.treehugger.com>

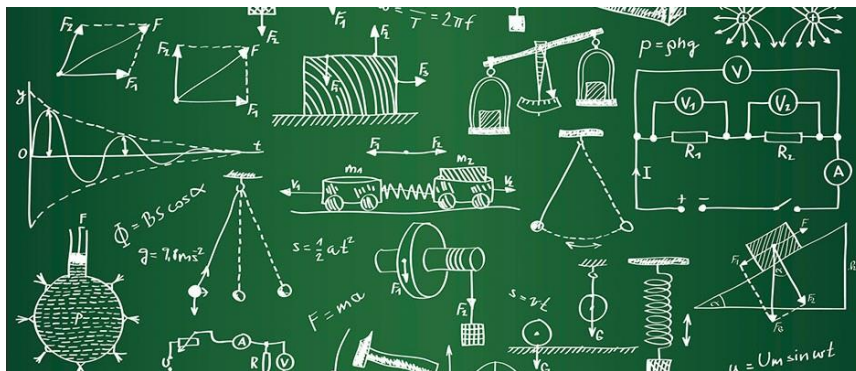
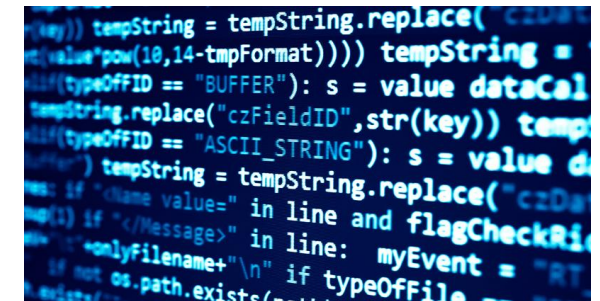


Source: [www.offshorewind.biz](http://www.offshorewind.biz)

From physics-based response to code-based response

System becomes more complex and non-linear

New phenomena and modelling and analysis becomes a lot more challenging



Source: <http://www.bbc.com>

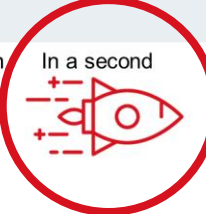




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# How to control grid frequency and voltage?

The Finnish challenge: small power system with large synchronous units and a lot of converter based production

We need new market places and technical solutions:

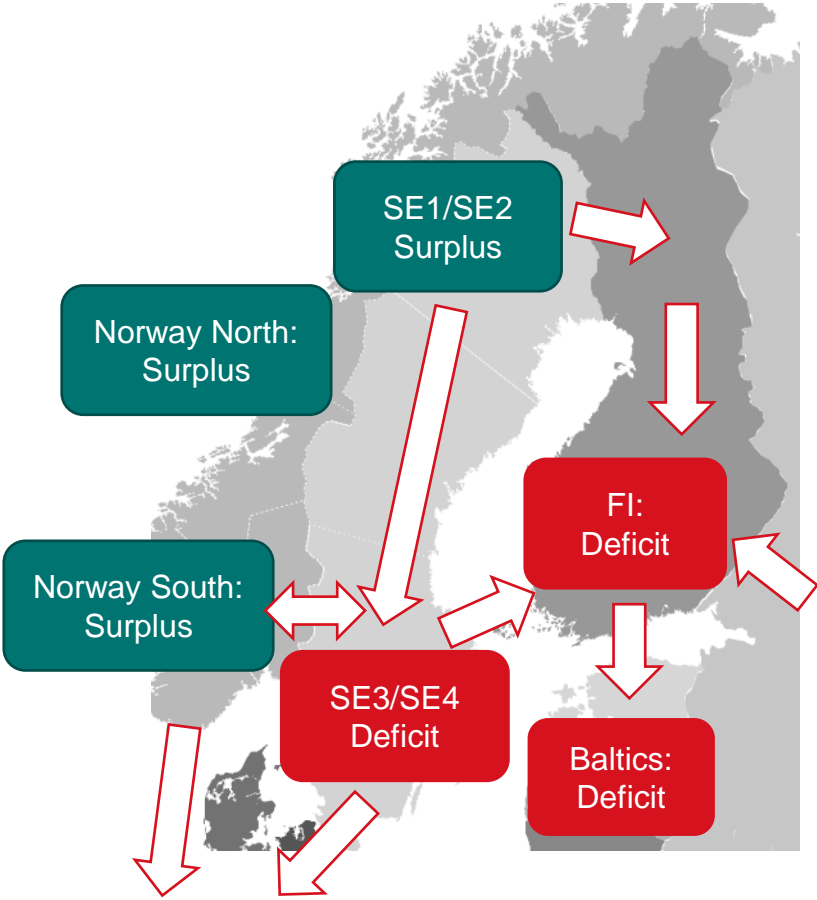
- New types of reserves, faster than before
- New technologies: synchronous condensers, batteries,...
- New connection requirements for converters and their controls
- New planning principles for grid, it's protection and control

	<b>FFR</b>	<b>FCD</b>	<b>FCRN</b>	<b>aFRR</b>	<b>mFRR</b>
	<b>Fast Frequency Reserve</b> In Nordics, total 0-300 MW (est.)	<b>Frequency Containment Reserve for Disturbances</b> , 220–265 MW In Nordics, total 1 200 MW	<b>Frequency Containment Reserve for Normal Operation</b> , 138 MW In Nordics, total 600 MW	<b>Automatic Frequency Restoration Reserve</b> , 70 MW In Nordics, total 300 MW	<b>Manual Frequency Restoration Reserve</b>
Activated	In large frequency deviations, only when the level of inertia is low	In large frequency deviations	All the time	During certain hours	If necessary
Activation speed	In a second 	Seconds 	A couple of minutes 	A couple of minutes 	Fifteen minutes 

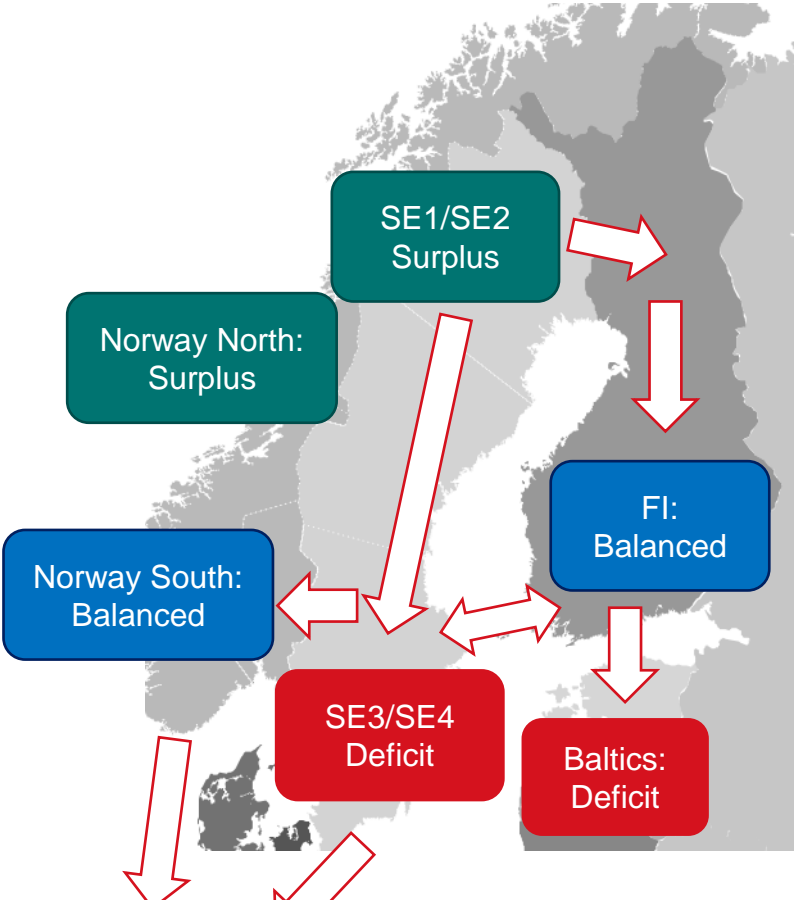
# Finland will turn into an exporter of electricity

But at the same time – more dependent on interconnections

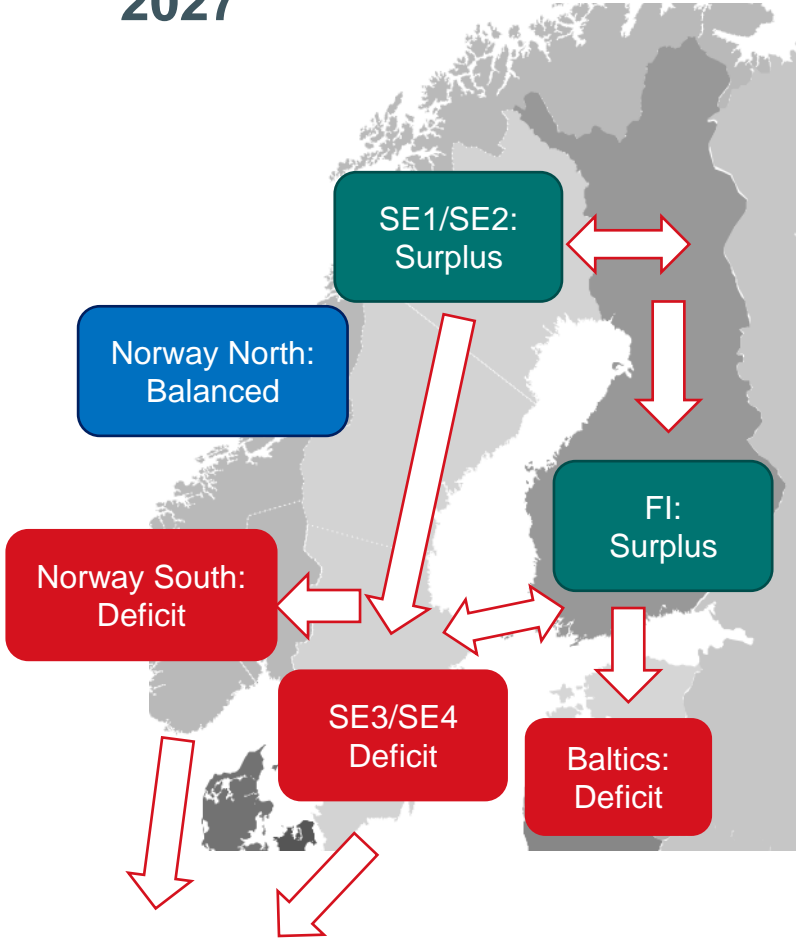
2021



2024



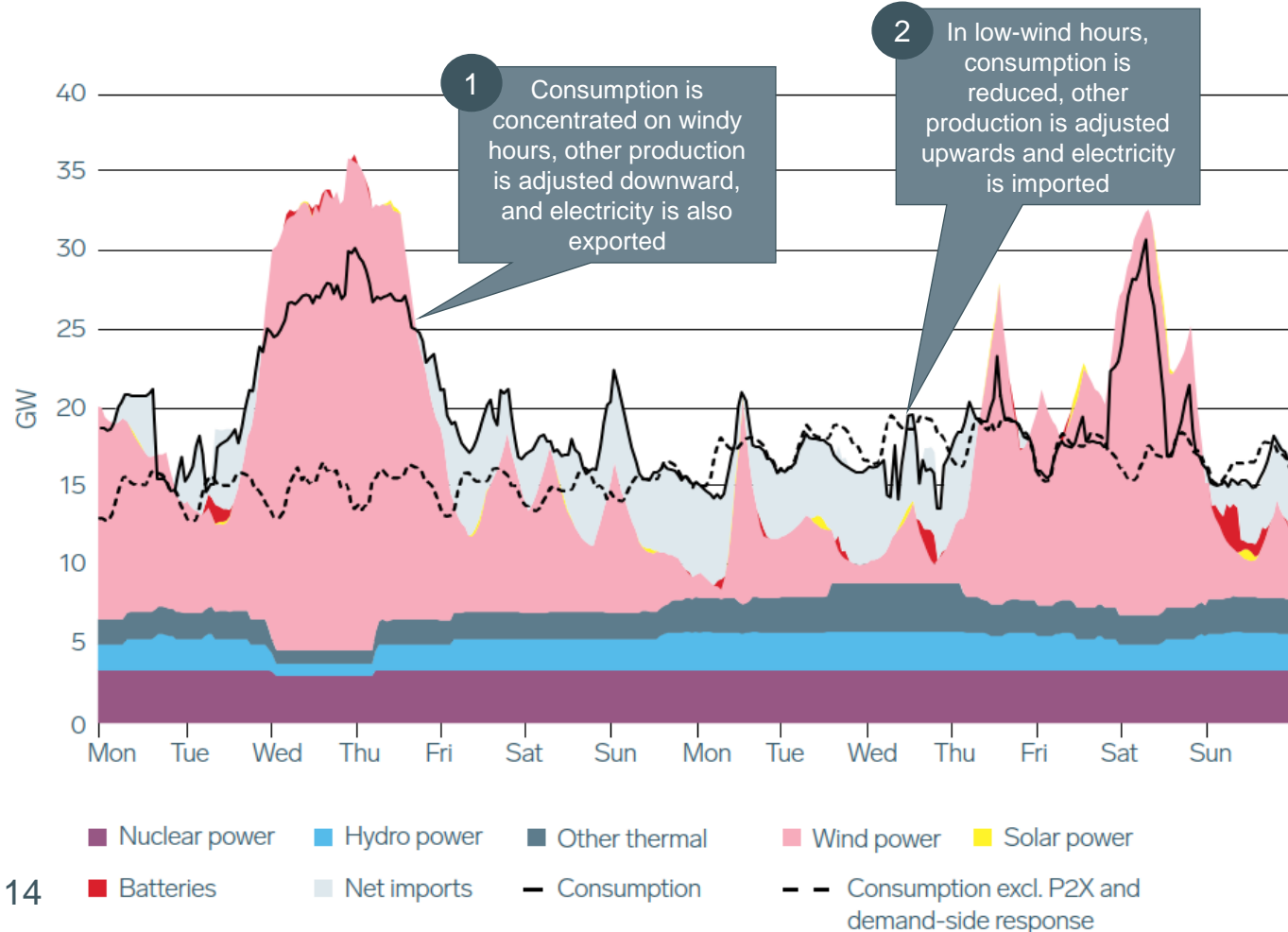
2027



13 Source: Fingrid Best Estimate scenario H2/2022. Direction of arrows refers to main direction of the power flow

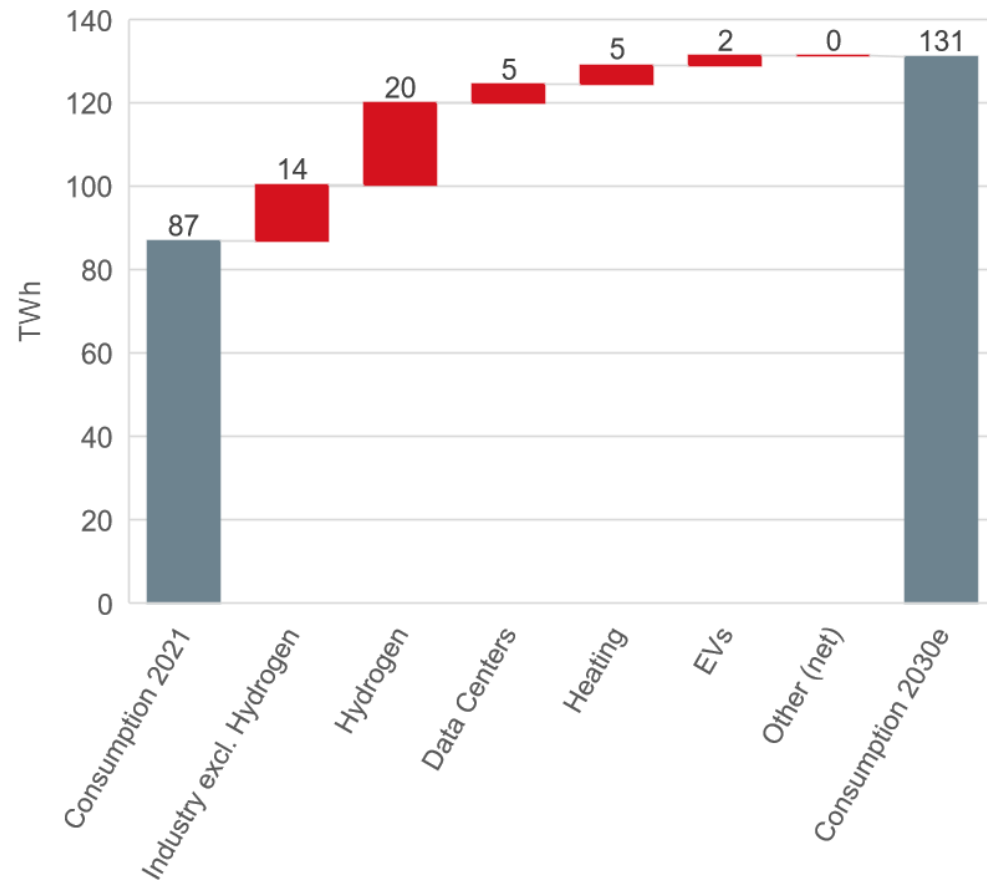
# Fluctuation of production is very large – all solutions are needed for balancing

Hourly electricity production and consumption in two winter weeks in a 2035 scenario:



- Wind power production at peak 27 GW, at its lowest less than 1 GW!
- The rest of the system needs to adjust according to wind power production:
  - Export and import of electricity
  - Flexible generation (hydro, CHP, ...)
  - Demand response and storages

# Growth in Finnish electricity demand coming from various sources – which ones can manage volatility?

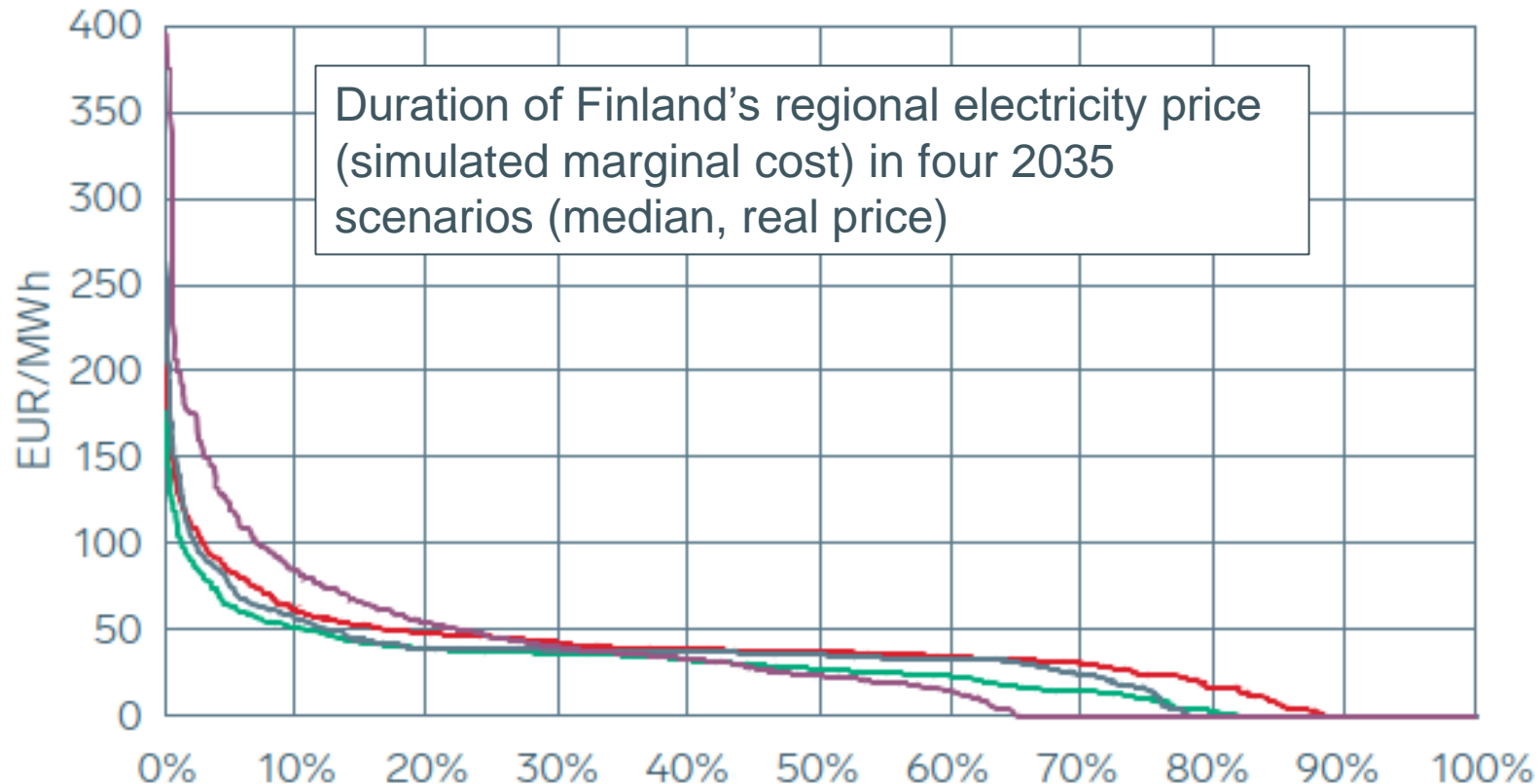


Source: Fingrid Best Estimate scenario H2/2022

## Technologies capable of managing volatility:

- Demand side response
  - ✓ Industrial process/heating flexibility and electric boilers
  - ✓ Smart EV charging
  - ✓ Residential load shifting
  - ✓ Data center UPS
- Energy storage
  - ✓ Batteries
  - ✓ Heat storage in district heating networks
  - ✓ Hydrogen storage
- Not one solution - all flexibility needed!

# However, electricity price will fluctuate



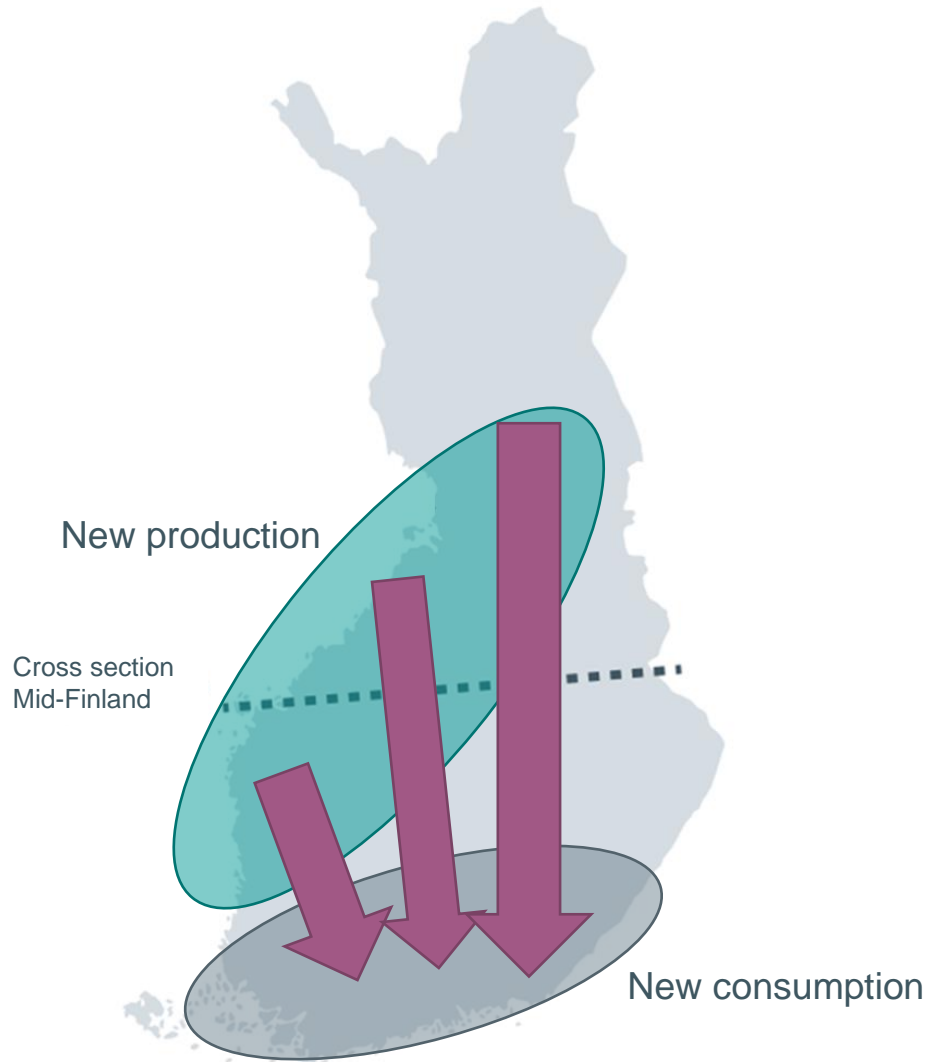
In the scenarios 10-35% of hours, the value of electricity is low → the proportion depends heavily on the amount of storage (hydrogen, heat, electricity)

Extreme price spikes are much rarer than low prices

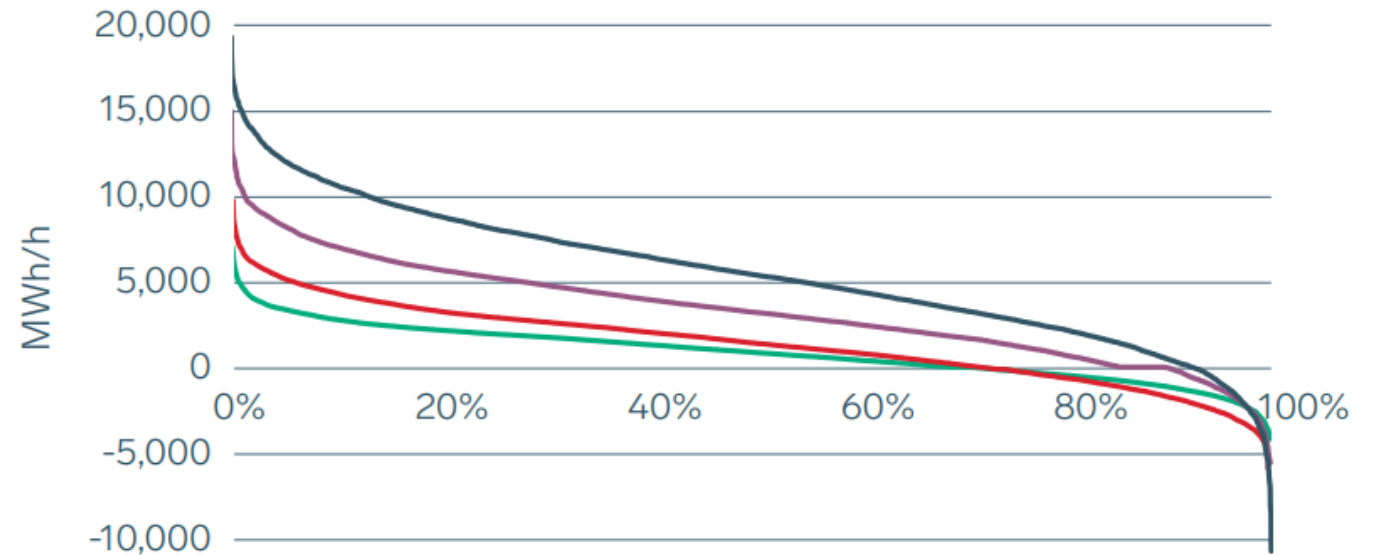
Price fluctuation will create incentives for energy storage and flexibility



# Finland to be kept as one price area

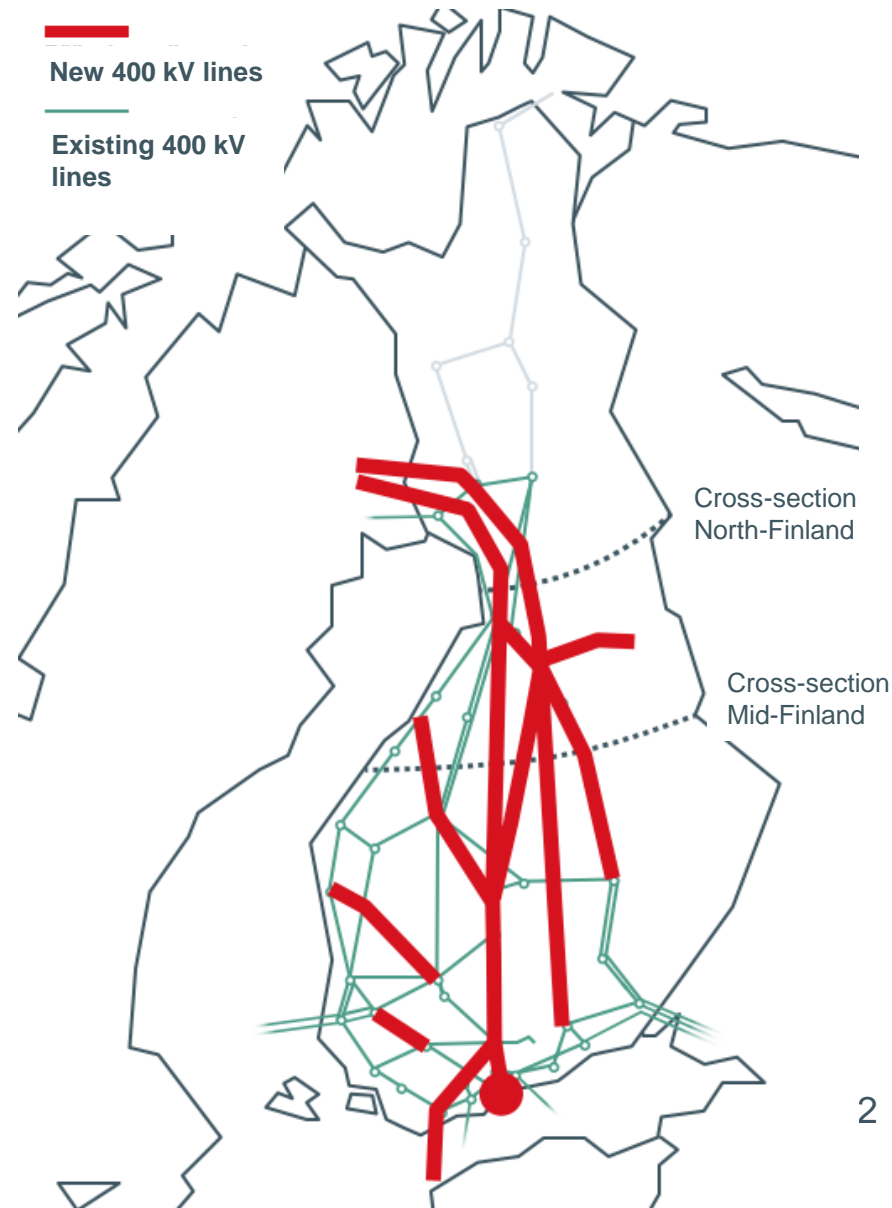


Transmission needs over cross-section central Finland in four 2035 scenarios (all energy transmitted as electricity\*)



\* hydrogen pipelines will help and also form a storage themselves

# Lots of new transmission grid needed



## 2022 – 2031:

- 3200 km of 400 kV transmission lines
- 2000 km of 110 kV transmission lines
- 50 km of HVDC cable
- about 200 substation projects (includes new substation projects, expansion projects and maintenance projects)

# Summary: how to manage the changes?



European-wide market places and strong interconnections, also for hydrogen



Market places corresponding to the physics of the power system



All market players, including consumers, steered by the market prices



All flexibility - old and new solutions - utilised for balancing and reserves

# Any questions?

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