The Electric Power system

Finland

For power system expertise

Power system of FINLAND

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1 Basic facts

- Area: 338 424 km^2
- Population: 5.5 million
- Number of electricity consumers: 346 000 (2018)
- 1 TSO, 77 DSOs (also 11 regional grid companies with 110 kV grid)
- Peak load 2019: 14 723 MW
- Average interruption of electricity 2019:
  - TSO SAIFI: 0.178 interruptions / connection point,
  - TSO SAIDI 4.27 minutes / connection point [1)]
  - DSO customer SAIFI: 7.12 (all), 2.63 (without AR, DAR, planned interruptions)
  - DSO SAIDI: 0.74 h/a (all) [2)]

1) https://www.fingrid.fi/globalassets/dokumentit/fi/kantaverkko/sahkonsiirto/transmission-reliability-to-homepages-2019_en.pdf
2) https://energia.fi/files/4972/Sahkon_keskeytystilasto_2019.pdf

2 Global map of the grid and of its interconnections

- Interconnectors with:
  - Sweden:
    - two 400 kV AC lines (red on the map)
    - HVDC bipolar link (violet on the map)
  - Russia:
    - HVDC back-to-back HVDC link
  - Estonia:
    - two HVDC links (violet on the map)
  - Norway:
    - one 220 kV AC line (green on the map)

Map from ENTSO-E:
https://eepublicdownloads.blob.core.windows.net/public-cdn-container/clean-documents/Publications/maps/2019/Map_Northern-Europe-3.000.000.pdf

3 Grid facts and characteristics 2018

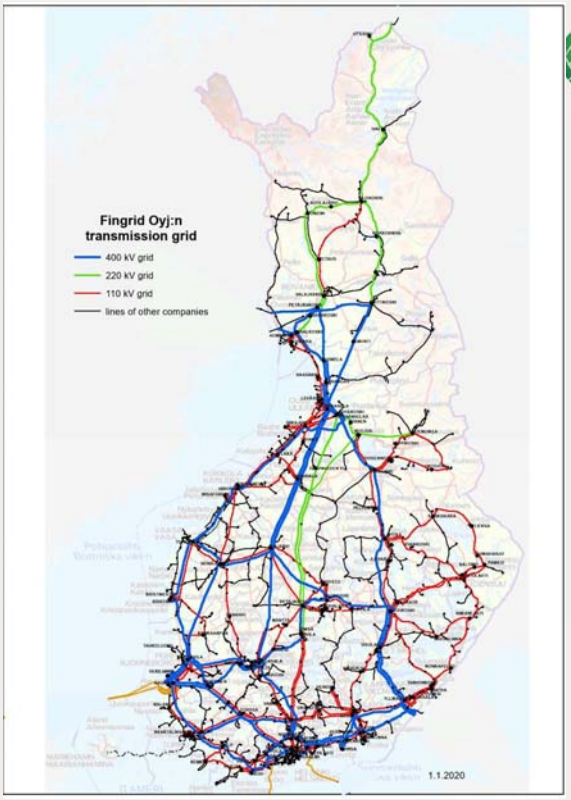
	Voltage level	Total length, approximately	Responsibility
Transmission grid	400 kV overhead line HVDC submarine cables	5 200 km 300 km	TSO TSO
Transmission grid	220 kV overhead line	1 600 km	TSO
Transmission and substransmission grids	110 kV overhead line 110 kV cable 110 kV overhead line 110 kV cables	7 300 km 50 km 9 000 km 20 km	TSO TSO DSO DSO
Distribution grid	1–70 kV (mostly 20 kV)	151 800 km	DSO
Distribution grid	400 V	249 200 km	DSO

Source: File 'Sähköverkkotoiminnan tekniset tunnusluvut 2018 (excel)' in the web page:
https://energiavirasto.fi/verkkotoiminnan-julkaisut

4 Structure of electrical power system

- The TSO: Fingrid Oyj
  - System responsibility, 14 100 km of 100–400 kV overhead lines, 116 substations
- Regional networks
  - connected to the main transmission grid, usually 110 kV lines
- Distribution networks
  - 0.4–110 kV grids, connected either directly to the transmissoin grid or use the grid services via a regional network
- Power plants and loads:
  - connected to a distribution, regional or to the transmission grid

5 Map of the transmission grid



Map:
https://www.fingrid.fi/en/grid/power-transmission/power-transmission-grid-of-fingrid/

6 Information on the TSO

- Name: Fingrid Oyj
- Network in January 1, 2020 :
  - overhead lines approximately:
    - 400 kV: 5100 km, 220 kV: 1300 km, 110 kV: 7300 km
  - HVDC cables to abroad[1)]:
    - 400–500 kV: 216 km, 150 kV: 53 km.
- Served area (km²), the entire country
- Annual transmitted energy (TWh): 68.7 in 2019 (76.0 % of the transmitted energy)
- Electricity transmission reliability: 99.9998 %
- website: https://www.fingrid.fi/en/

[1)] The ownership of the total cable length is shared between the corresponding remote end TSO

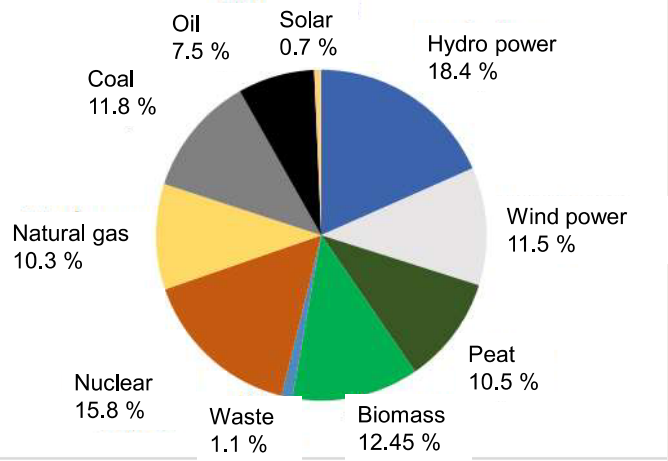
7 Responsibilities of the TSO and DSOs

- TSO
  - The TSO, Fingrid, is responsible for the functioning of the Finnish electricity transmission grid. Major power plants, industrial plants and regional electricity distribution networks are connected to the grid. The transmission grid serves electricity producers and consumers, enabling trading between them on a nation-wide level and also across national boundaries.
  - Fingrid is responsible for system supervision, operation planning, balance service, grid maintenance, construction and development, and promotion of the electricity market.
- DSO
  - Each local distribution grid is a natural monopoly, and requires a permit from the Energy Authority. The grid operator has to connect electricity consumers and producers into the grid and transmit electricity and take care of the voltage quality.

8 Installed capacity with reference to primary resources

At the end of 2018

Total	17.6 GW
– Biomass:	2.18 GW
– Coal	2.08 GW
– Gas	1.81 GW
– Hydro power	3.24 GW
– Nuclear	2.78 GW
– Oil	1.32 GW
– Solar power	0.12 GW
– Wind power	2.02 GW
– Peat	1.85 GW
– Waste	0.19 GW

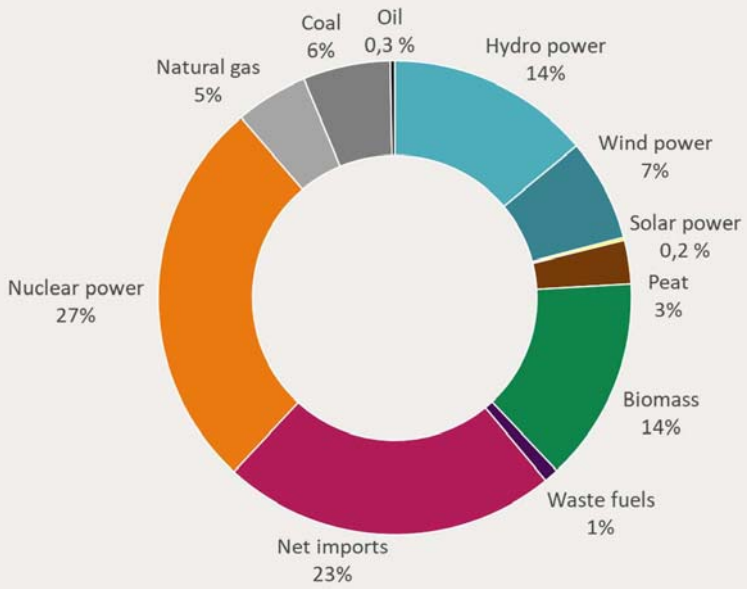


https://energiavirasto.fi/documents/11120570/12722768/Raportti-s%C3%A4hk%C3%B6n-toimitusvarmuus-2019.pdf/9d7138aa-8893-97e3-338d-a3559edb0c9c

9 Electricity by energy source

Total 86 TWh

- Nuclear 22.9 TWh
- Net import 20.0 TWh
- Hydro power 12.3 TWh
- Wind power 6.0 TWh
- Solar power 0.2 TWh
- Thermal power 25 TWh

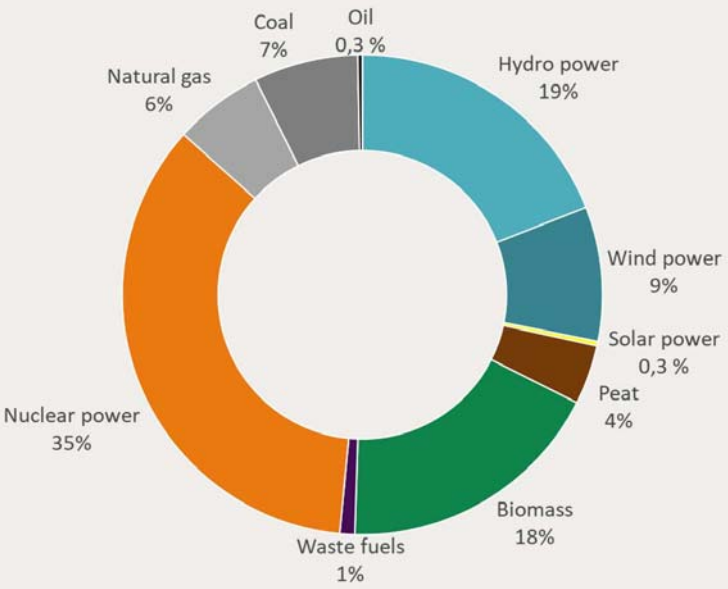


Source: https://energia.fi/files/4381/Energy_Year_2019_-_Electricity.pdf

10 Energy production in Finland by primary resources

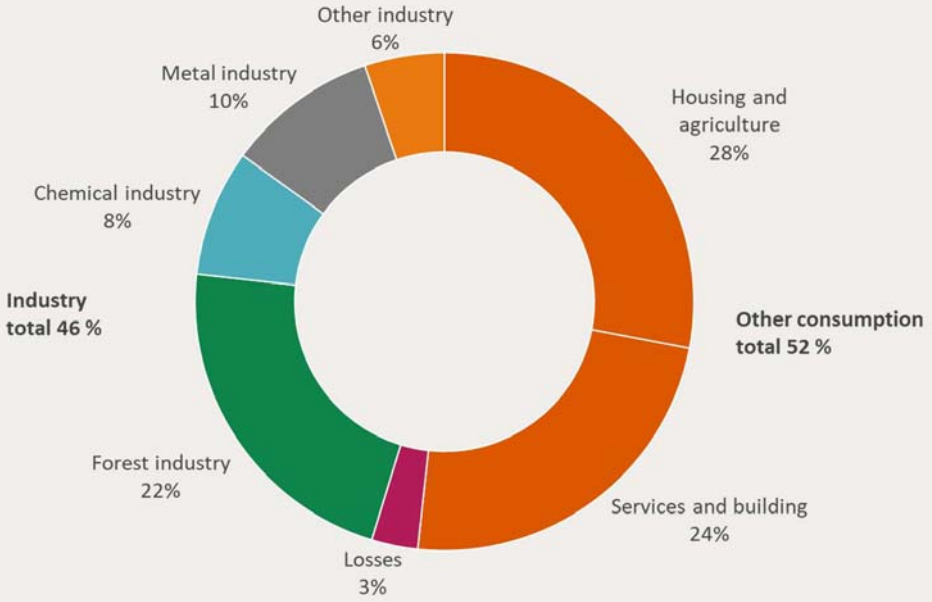
Total 66 TWh

- Renewables: 47 %
- Carbon dioxide free: 82 %
- Domestic: 51 %



11 Electricity consumption by customer group in 2019

Total 86 TWh



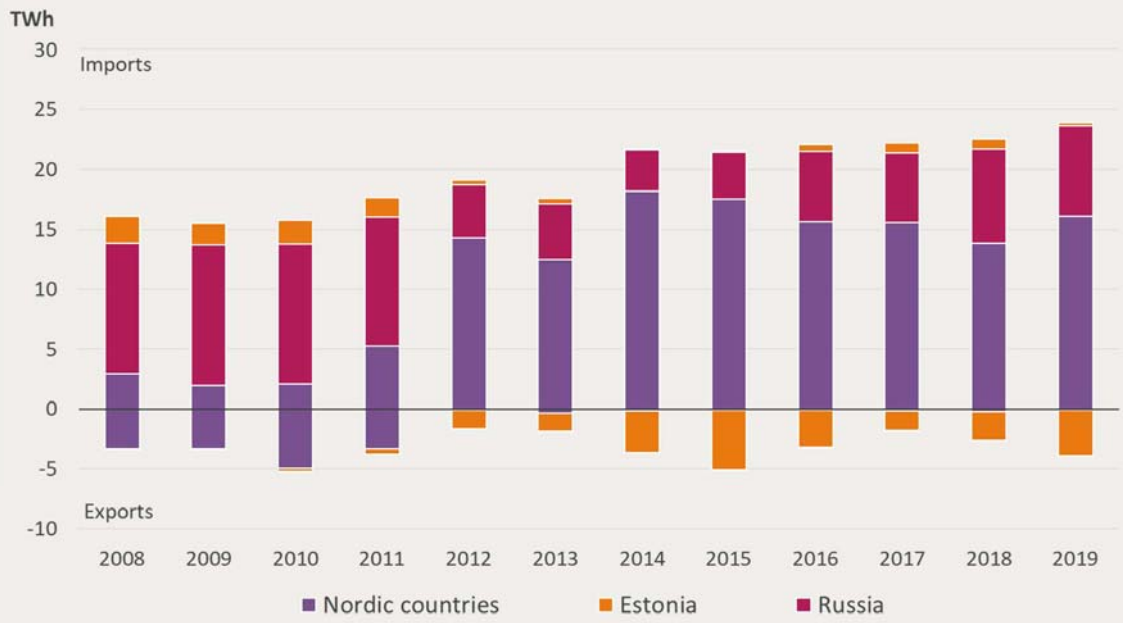
Source: https://energia.fi/files/4381/Energy_Year_2019_-_Electricity.pdf

12 Power balance in 2019

- Generation: 66 TWh
- Consumption: 86 TWh
- Net imports (TWh): 20 TWh
- Net exports (TWh): 0 TWh
- Losses: 2.6 TWh

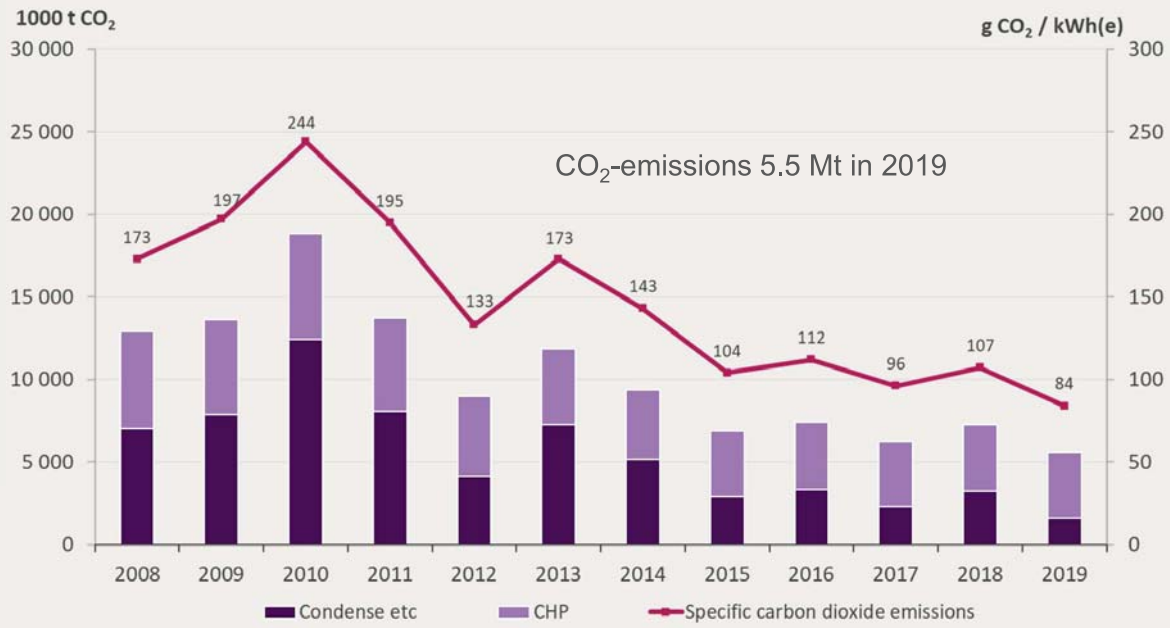
Source: https://energia.fi/en/news_and_publications/statistics/electricity_statistics

13 Imports and exports of electricity – development



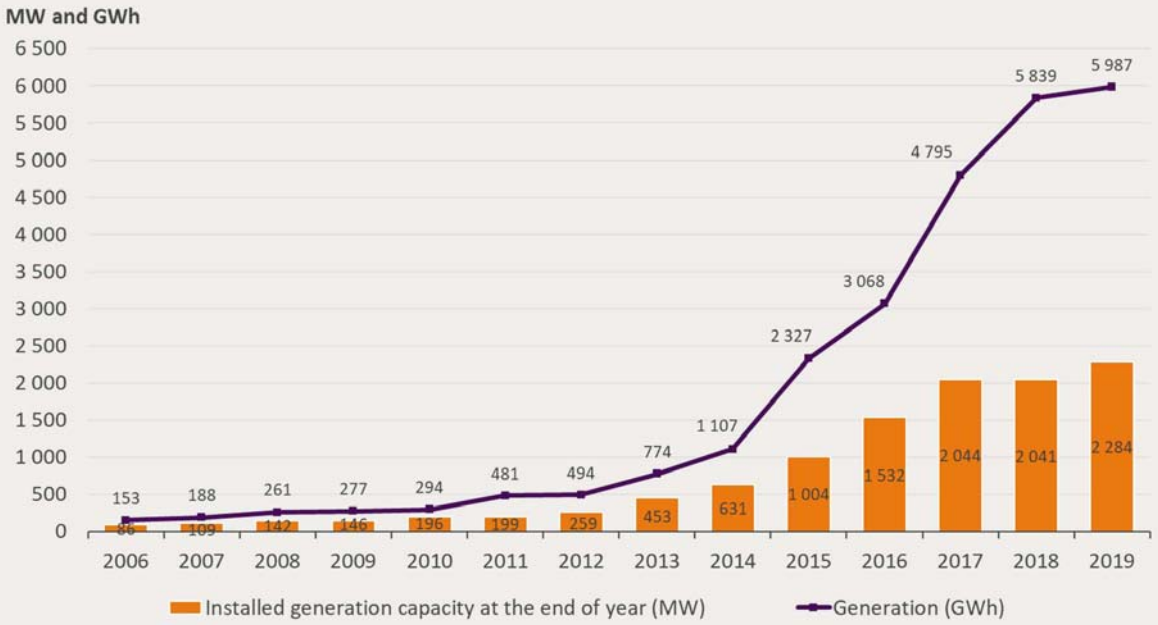
Source: https://www.fingrid.fi/en/electricity-market/market-integration/

14 CO2-emissions of power generation – Development



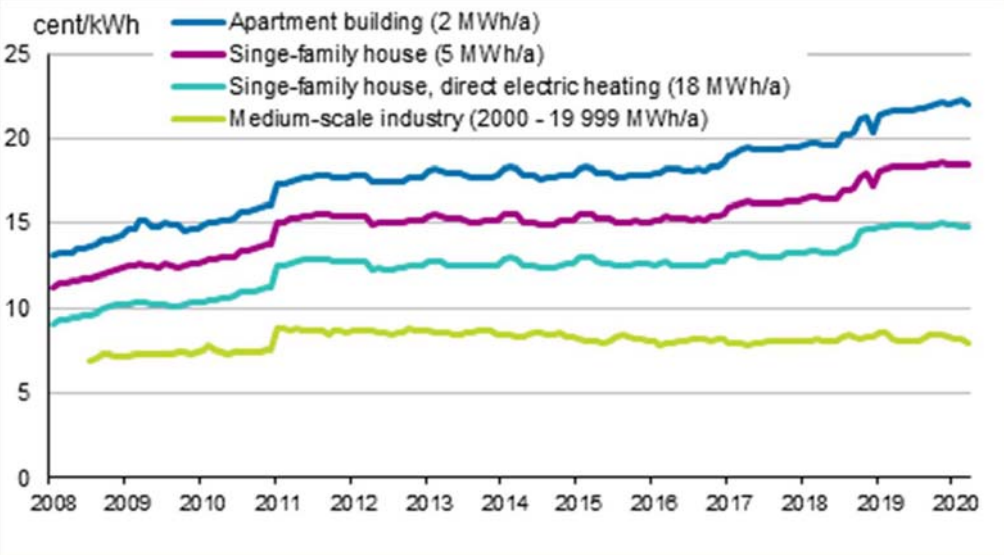
Source: https://energia.fi/files/4381/Energy_Year_2019_-_Electricity.pdf

15 Development of wind power



Source: https://energia.fi/files/4381/Energy_Year_2019_-_Electricity.pdf

16 Electricity price development for household and industry consumers

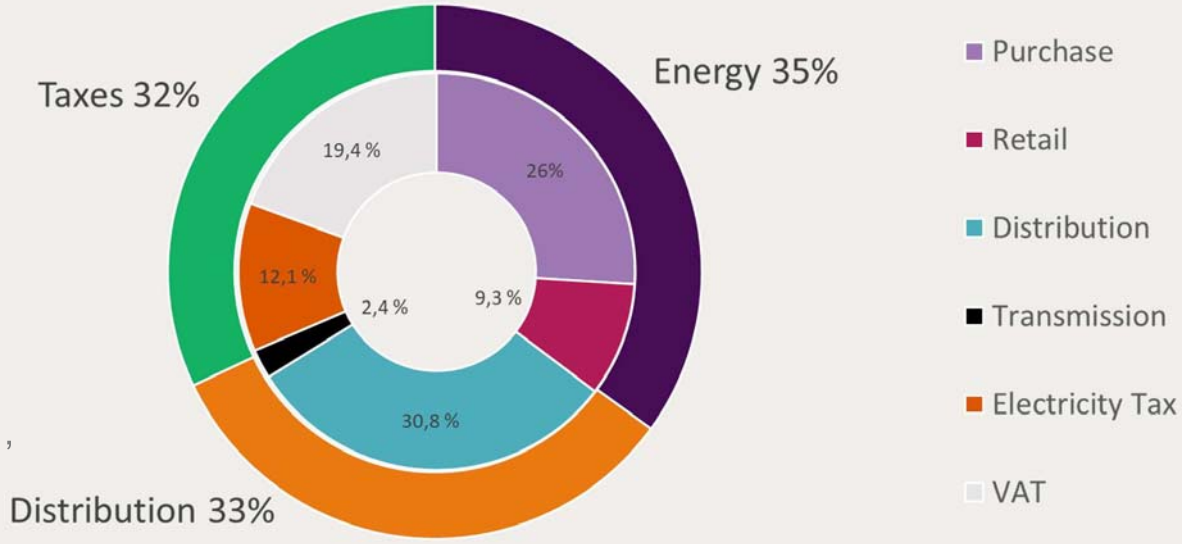


Statistics Finland: Energy prices [e-publication]. 1st Quarter 2020, Appendix Figure 5. Price of electricity by type of consumer.
Access method: http://www.stat.fi/til/ehi/2020/01/ehi_2020_01_2020-06-11_kuv_005_en.html

17 Price composition for a household

For a household consuming 5000 kWh / year

November 1, 2019



Source: https://energia.fi/en/news_and_publications/statistics/electricity_statistics

18 State of the Finnish power system

- State of the power system from the energy management system real time measurements:
  - Cross border power transfers in Finland
  - Production per primary source
  - Electricity market price in Finland
  - Available at:
    - https://www.fingrid.fi/en/electricity-market/power-system/

19 Electricity market organisation

- The Nordic countries are divided into bidding zones (with an unified price) according to the physical transmission capacity of the Nordic power system.
- Finland is a single bidding zone
- The congestions in the transmission lines between the bidding zones split the market area into separate price areas.
- Fingrid offers access to the European electricity market with its cross-border connections.
- Electricity prices and cross-border transmissions in the Nordic and Baltic countries available here: :
  - https://www.fingrid.fi/en/electricity-market/power-system/state-of-the-nordic-power-system/

20 Specific aspects of the electricity market

- Market coupling
  - The market algorithm considers market-based trade between bidding zones while the TSOs manage physical flows.
  - The Nordic TSOs collaborate on developing and implementing flow-based market coupling
- Nordic Multi-NEMO Day-Ahead Market Coupling implemented on June 3, 2020
  - NEMO: Nominated Electricity Market Operator
  - Project partners:
    - Nordic TSOs, three designated NEMOs, service providers and the Nordic Regional Security Coordinator (RSC)
    - More info: https://www.fingrid.fi/en/pages/news/news/2020/successful-go-live-of-nordic-multi-nemo-day-ahead-market-coupling/

21 Electricity market time frames

- Finland has day-ahead, intraday and balancing timeframes. Finance markets are used for long term protection.
- Day-ahead time frame:
  - daily implicit auction allocating the cross-zonal capacity simultaneously with electricity energy offers for each hour in the following day.
- Intraday time frame:
  - Continuous trading, where incoming electricity orders are executed one by one based on ‘first come first served’ principle as long transmission capacity is available.
- Balancing time frame
  - In the balancing timeframe national ancillary services are mainly applied, and the local TSO is the only buyer for these physical resources