Long-Term Finnish power balance and price development

How much renewables can be constructed and at which prices?

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SKM MARKET PREDICTOR

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30+ years

Norwegian company, established in 2000, part of SKM Group since 1992

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3 locations

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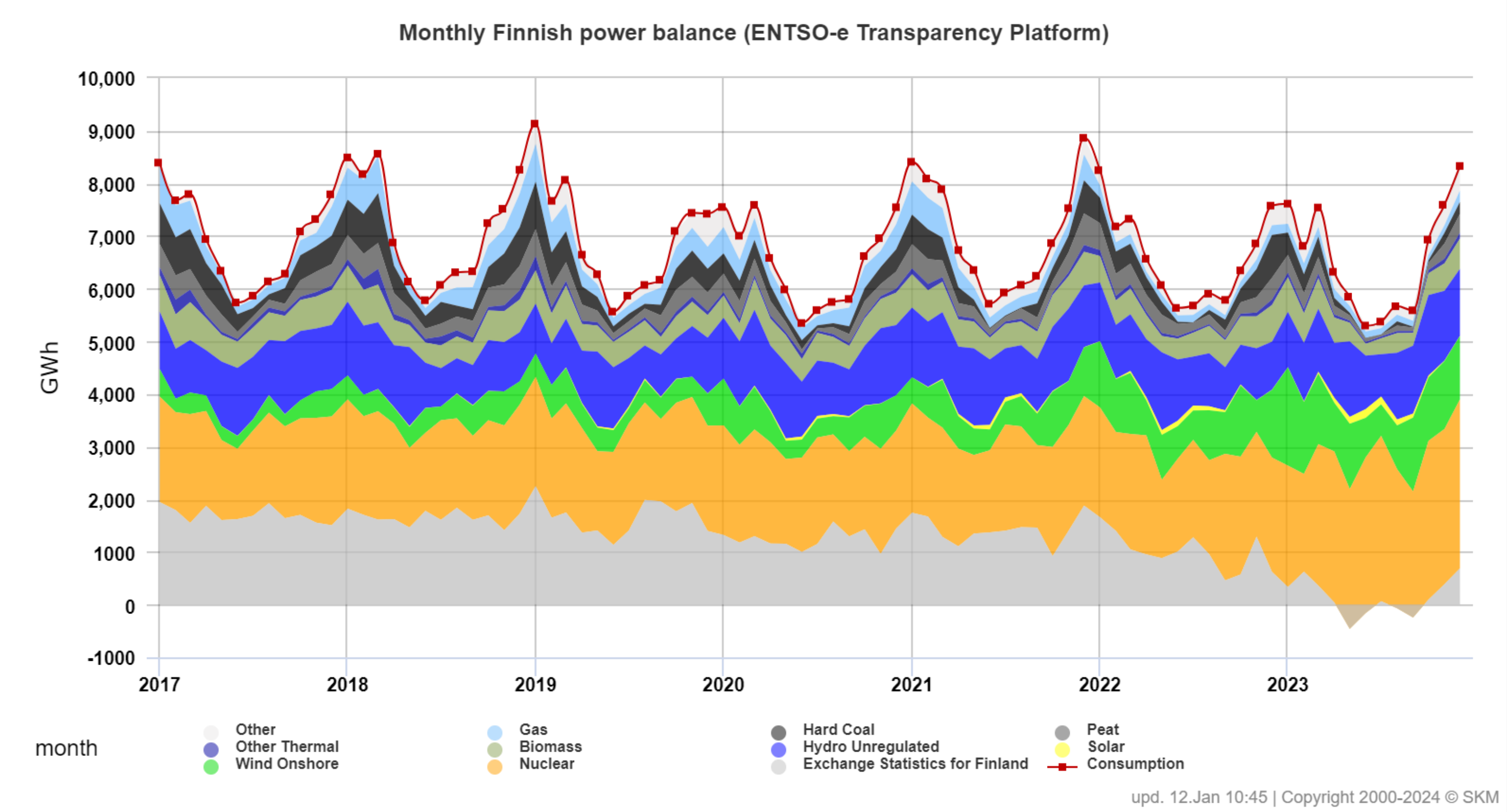
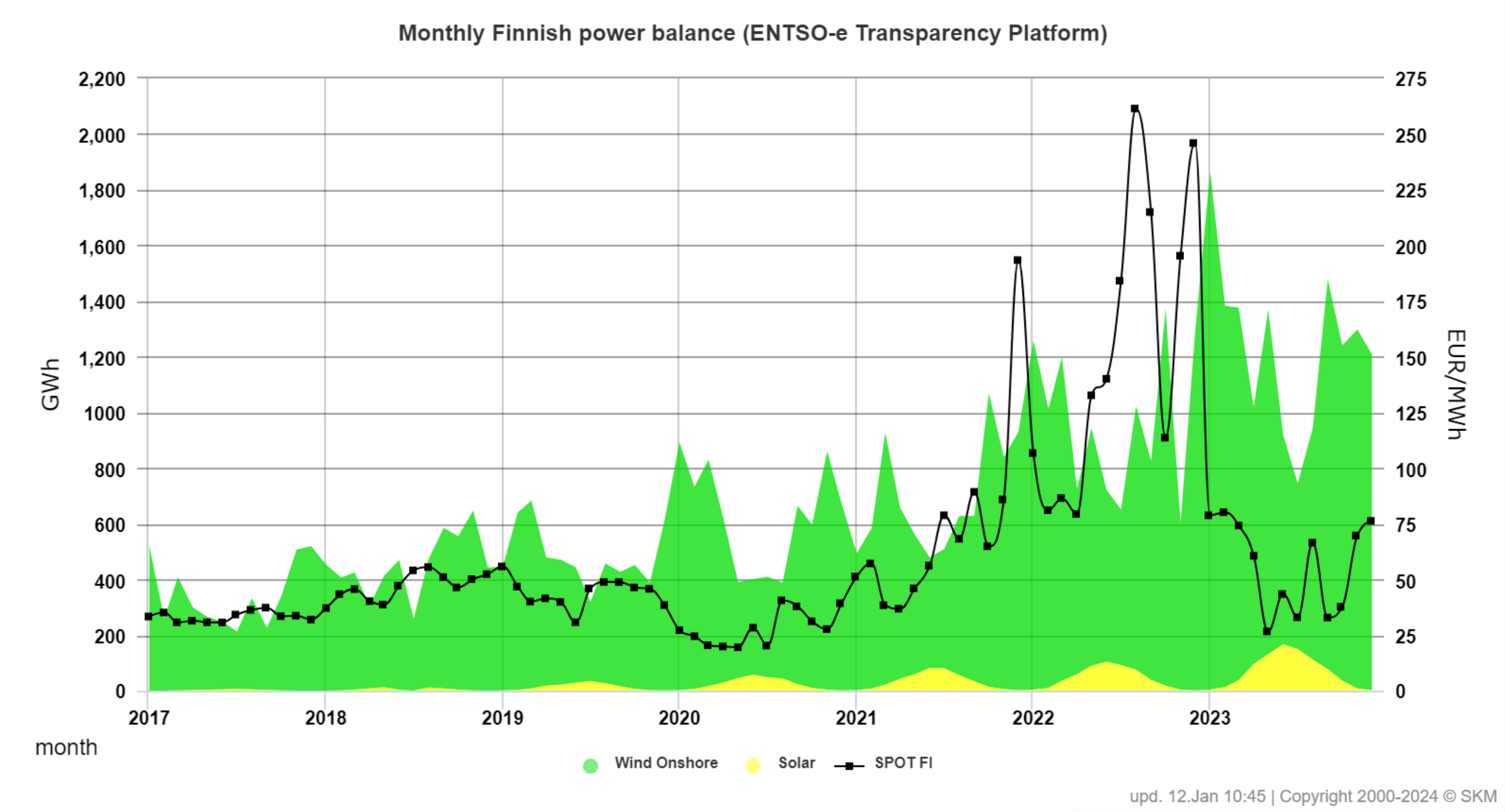
Development of Finnish power balance so far

- Finland's dependency on imports has diminished significantly over the last 5 year
- Net imports of electricity in 2023 went down to record low of 2.2 % of total consumption, 13.1 % down from previous year and 22.2% down from 2017
- Decommissioning of condensing production, introduction of renewables and phase-in of Olkiluoto 3 led to the increase of carbon-neutral production share in Finland up to 94% in 2023
- At the same time consumption has been on decline in recent years, mostly driven by forest industry
- Wind power generation grew by 25% from 2022 to 2023 and installed wind capacity more than doubled from 2021
- Lack of flexibility in Finland and whole Nordic region resulted in negative prices in 2020 and amount of those hit a record in 2023, accounting for 467
- The annual volatility of Finnish price in 2023 was in range of -500 EUR/MWh to 777 EUR/MWh. 1896 EUR/MWh price peak was registered on 5.1.2024, exposing the vulnerability of Finland's power system to the combination of high demand and low availability of renewables





Prospects for Finnish power balance

- Significant changes indirectly as the result of the Russia-Ukraine war resulting in -13 TWh supply shortfall from 2030
    - Cancelation of Russian imports to Finland with apx. 6 TWh at the same time prohibition of exports to Baltics with 3 TWh annual
    - Cancelation of Hanhikivi NPP 8 TWh planned from 2030s
    - Increased level of thermal commodities and stronger connection to the Baltic/European prices
- Opportunity window for renewable generation construction, however the gap will be closed gradually due to construction time lags
- Higher prices in the Baltic countries continue to have visible impact on the Finnish power prices formation through Estlink and NordBalt interconnectors
- In June 2022, a MoU has been signed for construction of 3rd Estlink interconnector with capacity 700-1000 MW with planned start-up in 2035
- Based on the balance issue we assume construction of one more nuclear unit +1200 MW in Finland from 2040s and extension of lifetime Loviisa 1&2 till 2040 and Olkiluoto 1&2 till 2050s

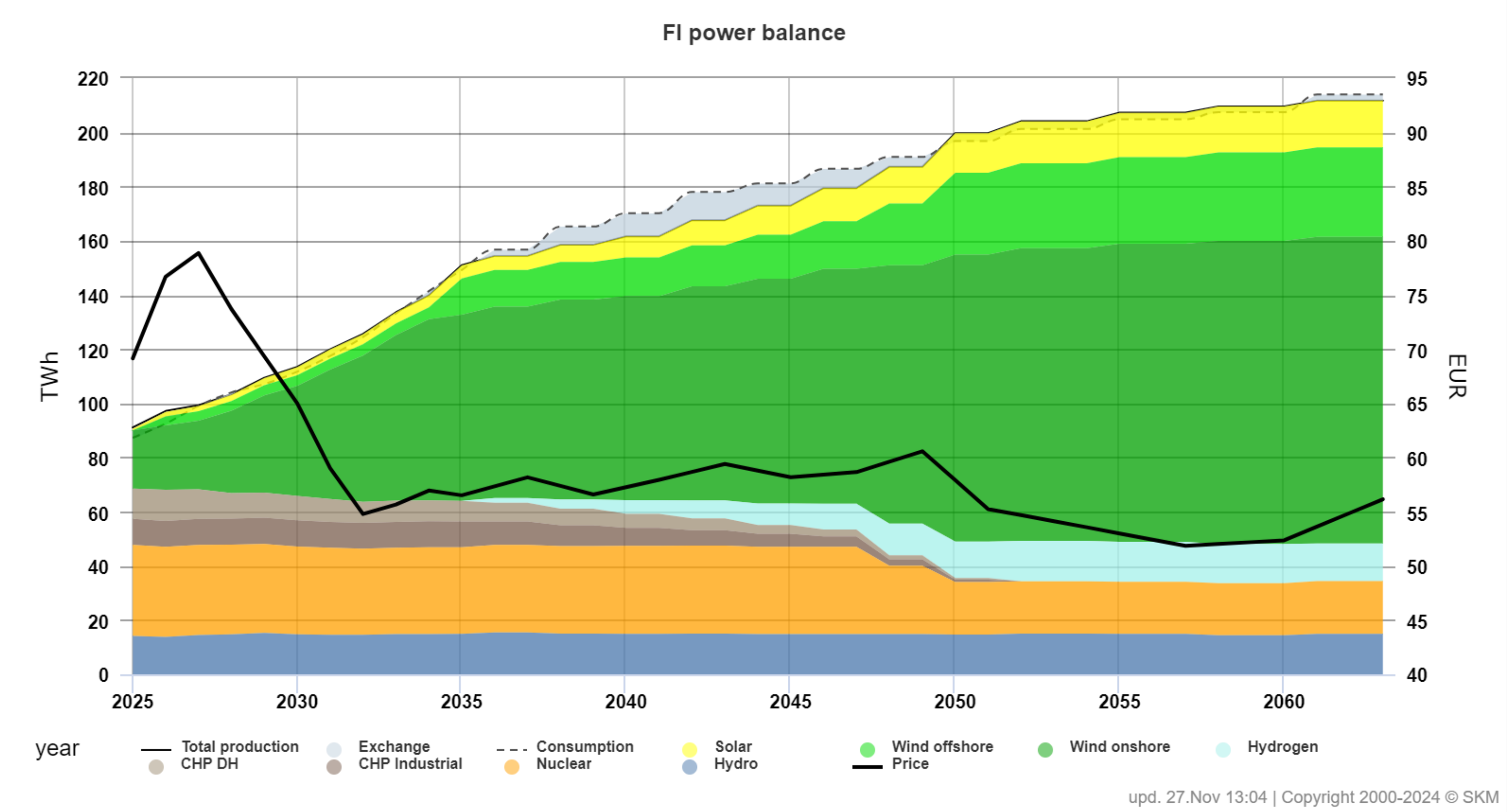
- Fingrid's long-term scenarios from 2022 assumes significant electrification of all sectors and **new** construction of:
    - Onshore wind: 28-101 TWh (2035) , 31-239 TWh (2045)
    - Offshore wind: 6-71 TWh (2035) , 6-143 TWh (2045)
    - Solar: 4-11 TWh (2035) , 7-25 TWh (2045)
    - Electrolyzes demand: 13-58 TWh (2035) , 16-202 TWh (2045)
    - Storage capacities: 1-3 GW (2035) , 1-6 GW (2045)
- Despite significant variations in the scenarios a strong increase of RES, demand flexibility necessity are expected
- Strong growth in RES primarily onshore wind will continue, solar expected also to increase significant, strong uncertainty related to offshore wind electrolyzers development
- Future RES captured prices, balance development, political decision and decrease of technology costs will have major impact on the future prospects for RES capacity increase

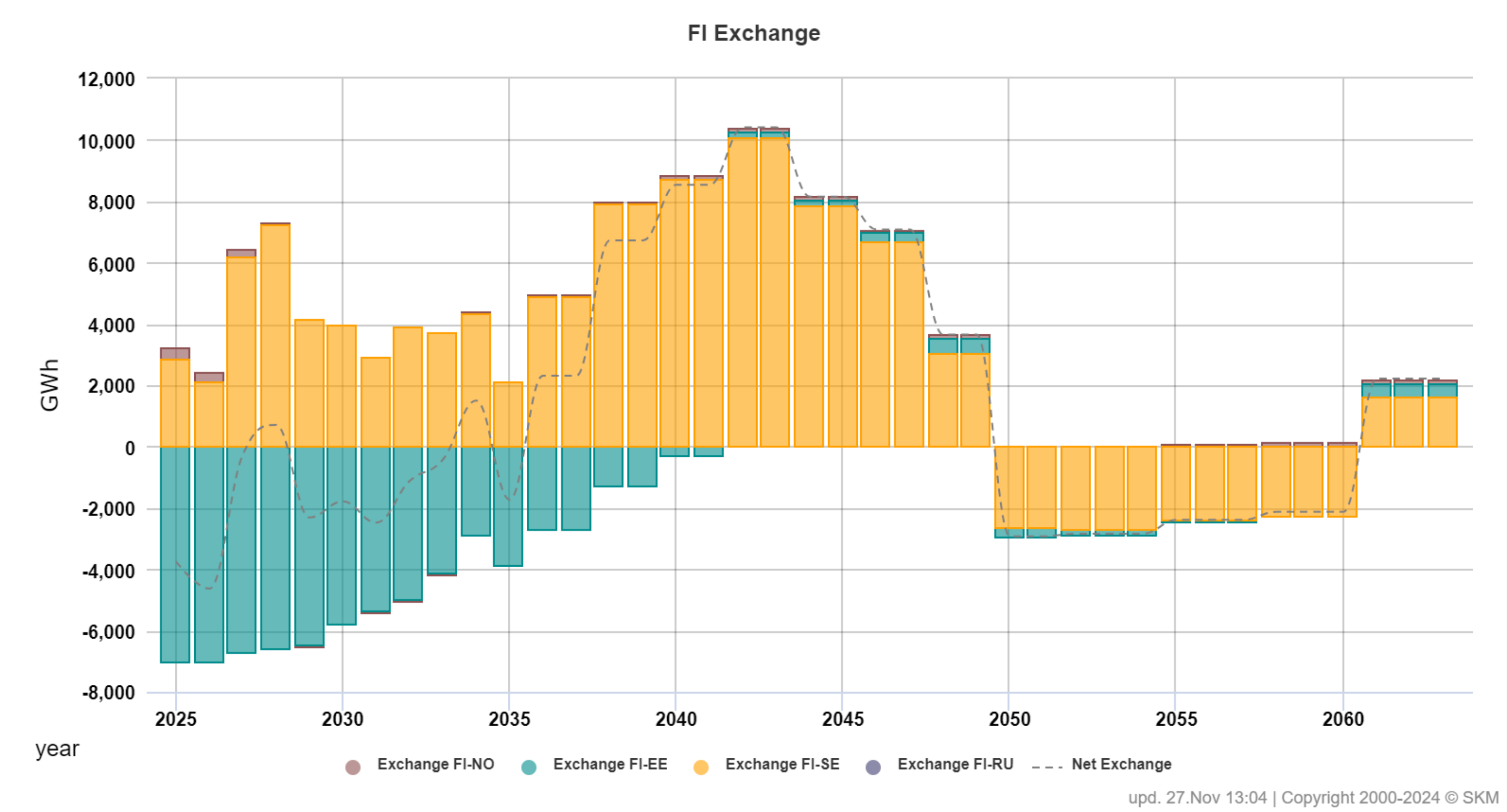
Finland's power balance – SKM assumptions

- Reduced import supply and expected increase in demand triggers construction of significant RES production in our Base scenario

Year	Onshore	Offshore	Solar
2035	55 TWh	12 TWh	4 TWh
2045	70 TWH	16 TWh	10 TWh

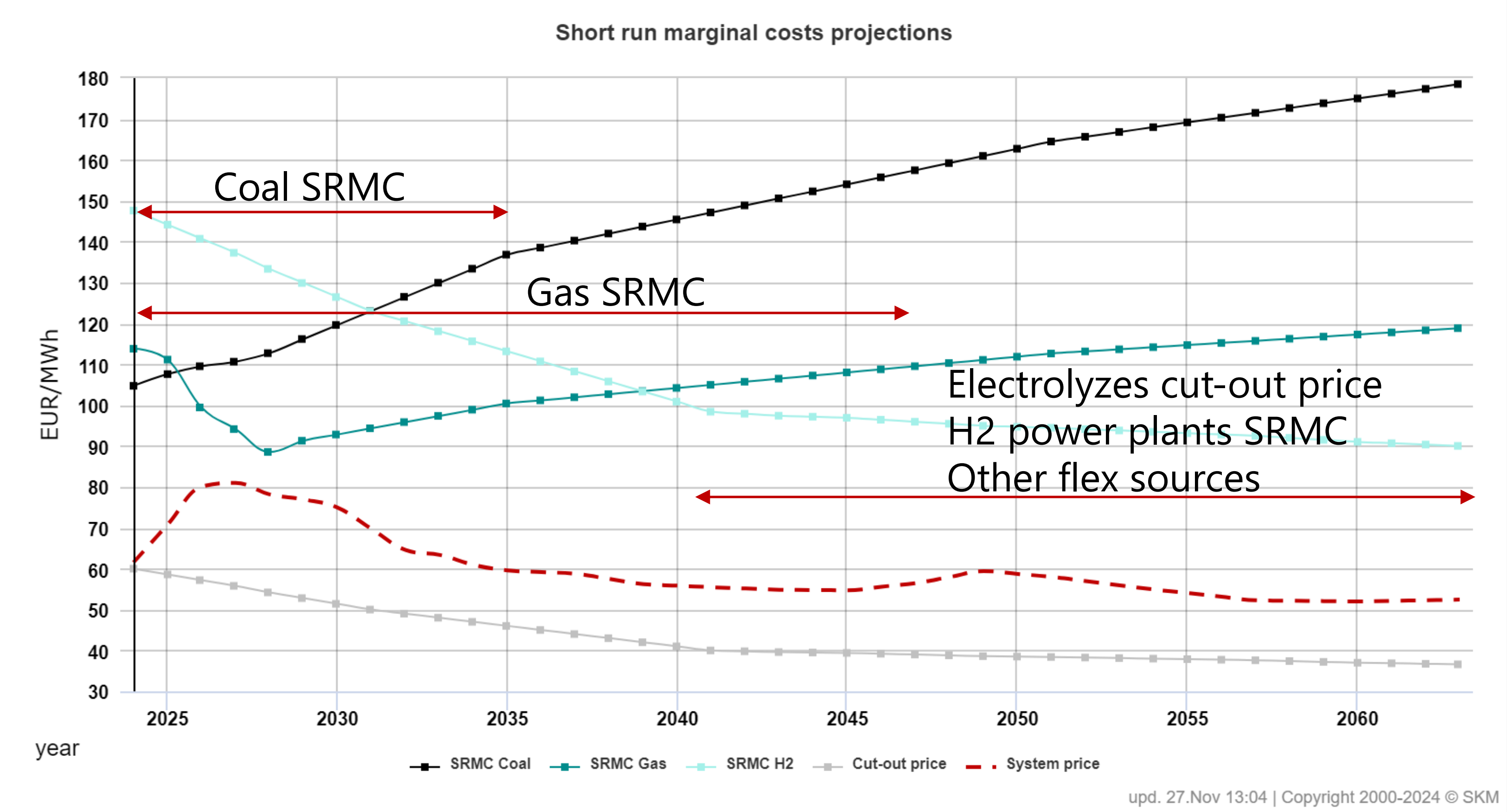
- Electrolyzers' consumption goes up with 30 TWh (2035) and 40 TWh (2045). Still at the lower level of Fingrids assumptions as H2 requires strong subsidies or additional support framework
- While our estimates for onshore wind and solar are close to the average Fingrid's expectation we assume significantly less offshore wind construction in the years to come due to:
  - Hydrogen costs and demand, LHOE development–strong uncertainty
  - Offshore wind LCOE development – remain bellow price forecasts and need to be subsidized
  - Strong expected reduction of capture rates and high costs of flexibility posses a significant challenges
- Finland is a net exporter until 2035s due to higher prices, phase-out of domestic thermal generation and slower RES development in Baltics
- Sweden remains net importer to Finland until nuclear phase-out due to lower prices, oversupplied situation and new interconnectors to SE2

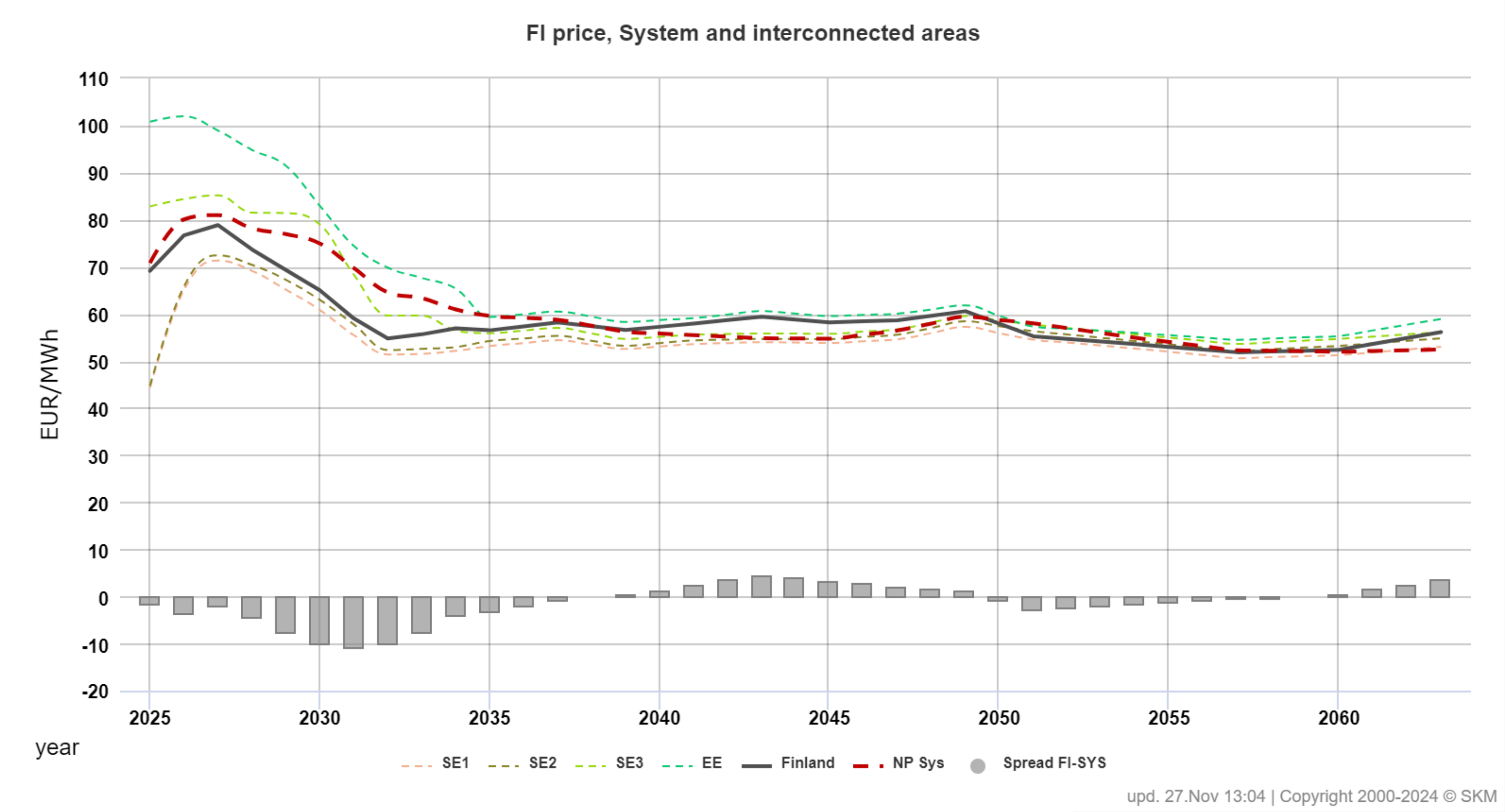




Finland’s power price development

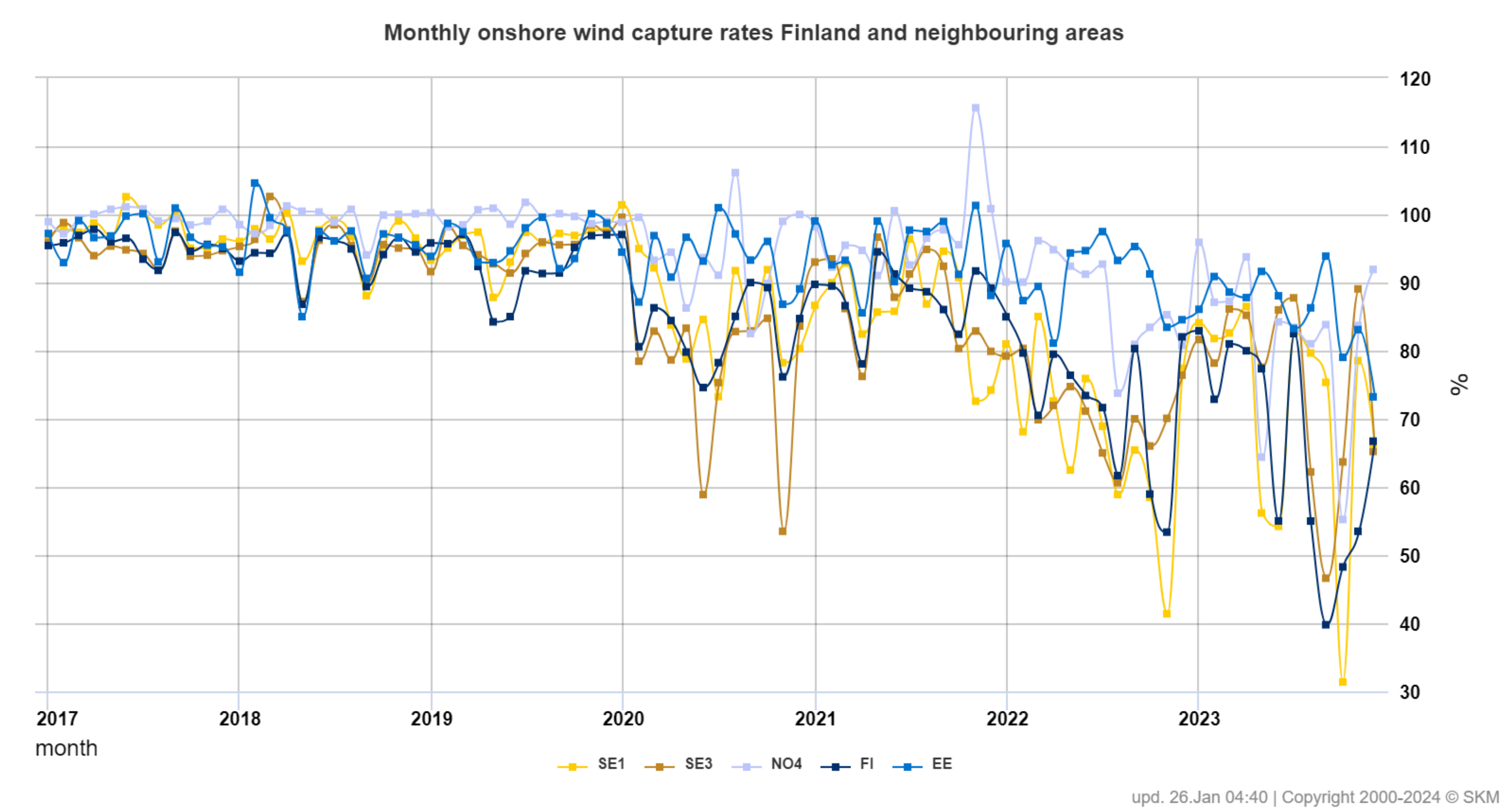
- Coal and gas prices expected to normalize once Russian deliveries are completely replaced with other alternatives
- We assume that CO2 price will be increasing and used as the regulation mechanism for decarbonization providing support for power prices
- Increased level of thermal prices and constrained situation in Finland and Baltics support price level in next few years
- Until 2030-2040, the prices are still supported by increasing SRMC costs due to higher CO2 prices
- Strongly increasing share of price independent RES production puts downward pressure on the prices
- From 2030-2035, H2 price gradually starts impacting the power prices and from 2040-2050 neither CO2 nor commodity prices have any major impact, as power balance is becoming carbon neutral
- Electrolizers’ demand increases significantly. Cut-out price will set power prices on the downside
- Phase-out of thermal units require H2 peak power plants in place, which will set prices on the upside
- From 2040-2045 the average Finnish price is set mainly by cut-out prices of electrolyzers, SRMC of H2 peak power stations and impact from European and Baltics markets





Onshore wind capture rates

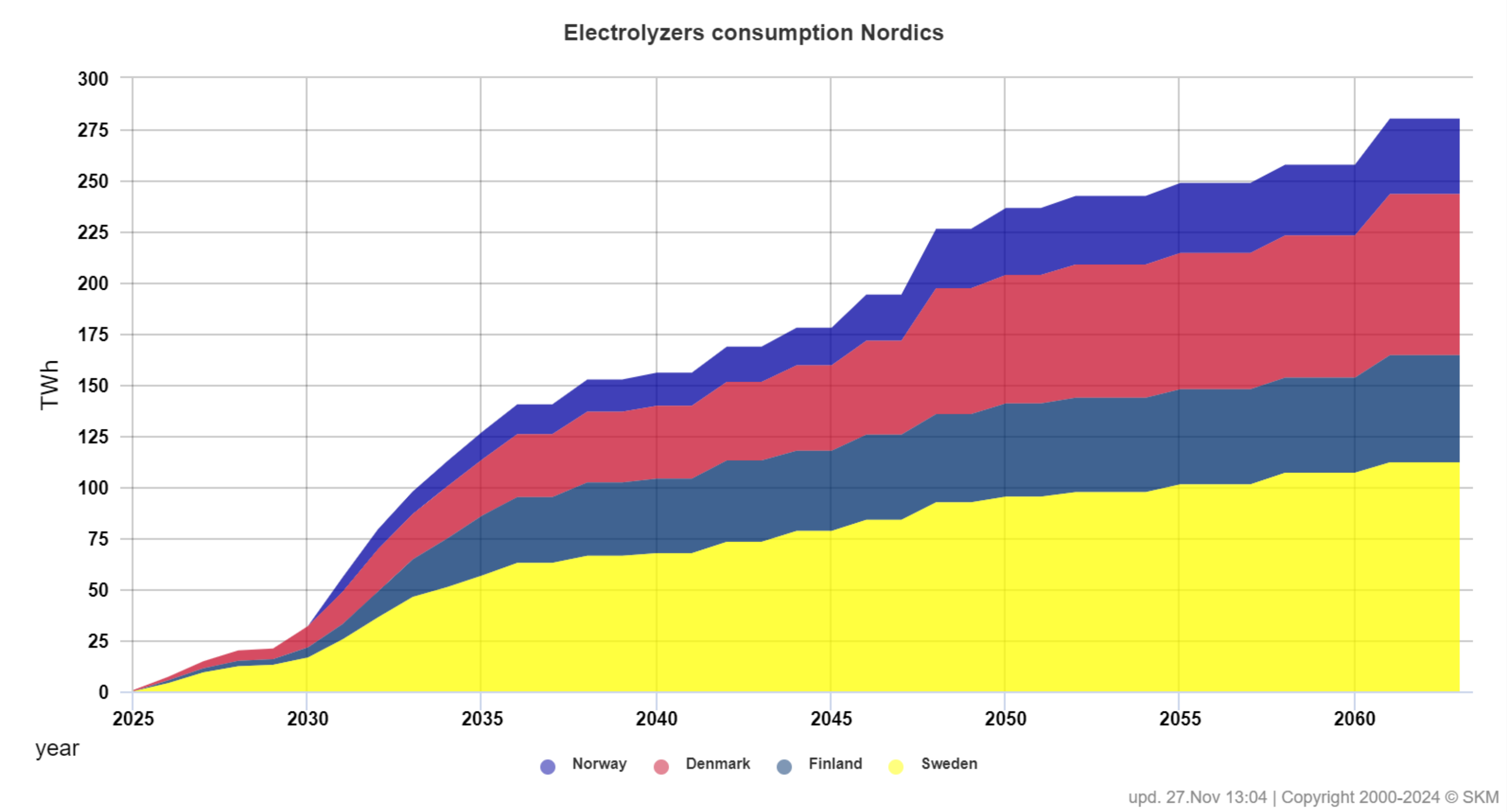
- Volatility in the power markets is expected to increase along with increasing RES production.
- Hourly spot price will be pushed downwards during periods of high wind production resulting in the cannibalization phenomenon
- Hourly wind captured prices will normally be lower compared to the average power prices.
- Correlation in wind production across entire Nordics and Western Europe further reinforce cannibalization effect
- The level of capture rates varies and depends on:
    - Share of intermittent production
    - Share of flexible power capacity
    - Connections to and the characteristics of the neighboring price areas with possibility to provide flexible exchange flows.
    - Amount of flexibility sources such as storage and hydrogen electrolyzers
- Annual decline in Finnish onshore wind capture rates has been dramatic in 2022 with 24% decline and in contrary to other areas didn’t recover in 2023 being one of the lowest across all price areas
- YoY and MoM variations are natural however the overall trend will be a strong decline until enough flexibility sources are constructed in the power system

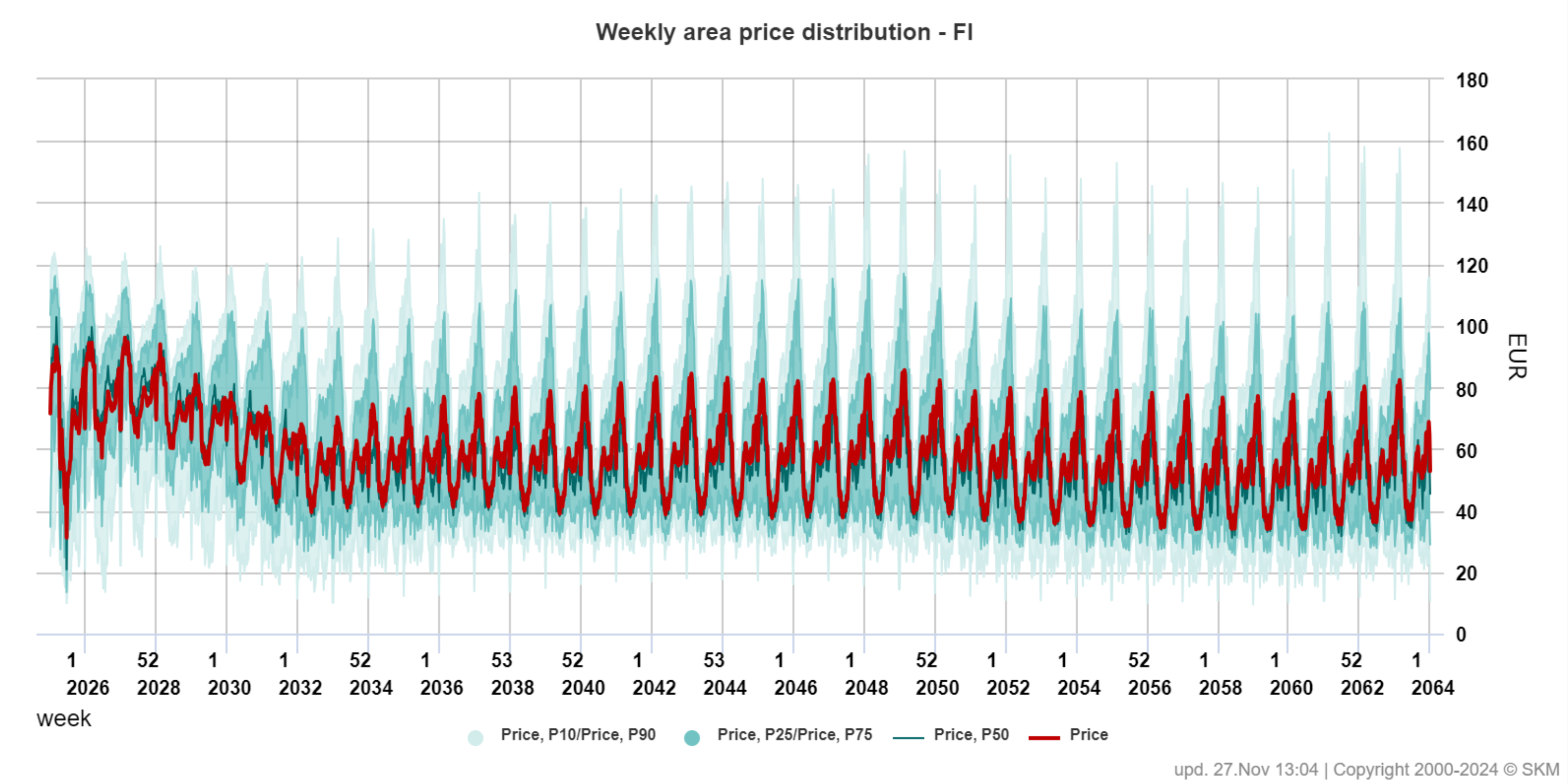


Year	DK1	DK2	SE1	SE2	SE3	SE4	NO1	NO2	NO3	NO4	FI	EE	LV	LT	DE	UK	PL	NL	FR
2017	86.4	88.5	97.9	95.7	94.8	93.1		99.7	99.0	102.7	95.1	96.6	95.5	95.7	80.5	99.8	91.8	95.5	98.6
2018	89.2	89.7	97.5	95.5	95.2	93.6		98.4	95.7	97.7	94.5	96.0	96.3	94.6	84.2	99.6	91.5	95.8	95.9
2019	89.5	90.9	96.7	97.1	96.7	95.7	94.0	100.2	97.5	100.9	92.8	95.4	94.1	94.2	85.9	97.8	92.5	105.5	94.7
2020	72.8	76.5	89.9	87.8	79.7	77.4	115.7	107.3	105.1	105.4	84.8	90.7	87.9	88.1	80.9	97.3	93.5	90.7	95.5
2021	83.7	81.5	83.5	79.4	88.7	86.0	102.9	102.3	87.1	100.9	93.5	98.8	90.7	94.4	83.2	97.7	95.1	100.3	93.9
2022	73.1	70.2	66.6	59.5	68.4	67.6	89.6	88.3	85.5	98.8	71.2	82.6	90.5	79.6	71.5	87.9	83.7	79.9	84.9
2023	75.9	74.9	78.3	72.1	80.7	77.4	104.6	90.9	89.3	95.5	71.6	86.7	82.9	83.1	82.5	93.7	87.2	88.0	89.2

Electrolysers' consumption impact

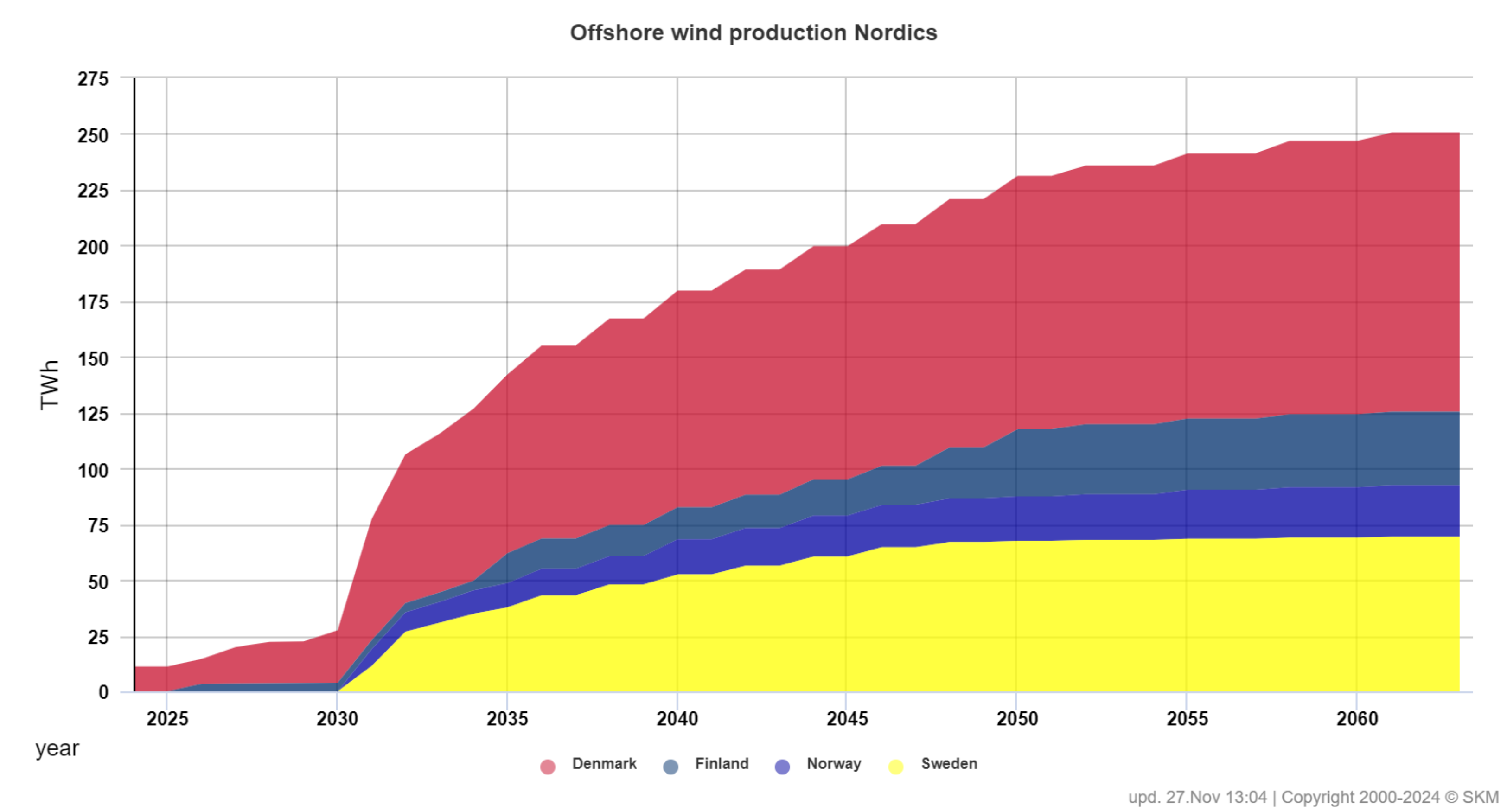
- The cost of renewable power is the single most important source of competitive renewable hydrogen, as power makes up about half of the production price. After that, the capital investment of the electrolyzers also significantly contributes to the cost of renewable hydrogen.
- Bloomberg estimates that the CAPEX of electrolyzes will be reduced by to 70 % in 2030 and 90 % by 2050 in Europe. Hydrogen strategy for climate neutral Europe expects electrolyzes prices to halve in 2030. This seems to be overoptimistic
- The amounts of green H2 produced in the Nordics are expected to be very significant, standing for 20% of total consumption and 30% by 2060 of total consumption.
- The H2 demand flexibility assumes that the cheapest hours are utilized, and green hydrogen sold at market prices. When electricity prices rise above a certain threshold, electrolyzers stop producing.
- Increased electrolyzers' demand for the cheapest hours will lift the prices and flatten the price fluctuations in the long perspective.
- This will also contribute to improving capture rates, particularly for wind, which is expected to flatten from 2035-2040s along with the increase of the electrolyzers' capacities

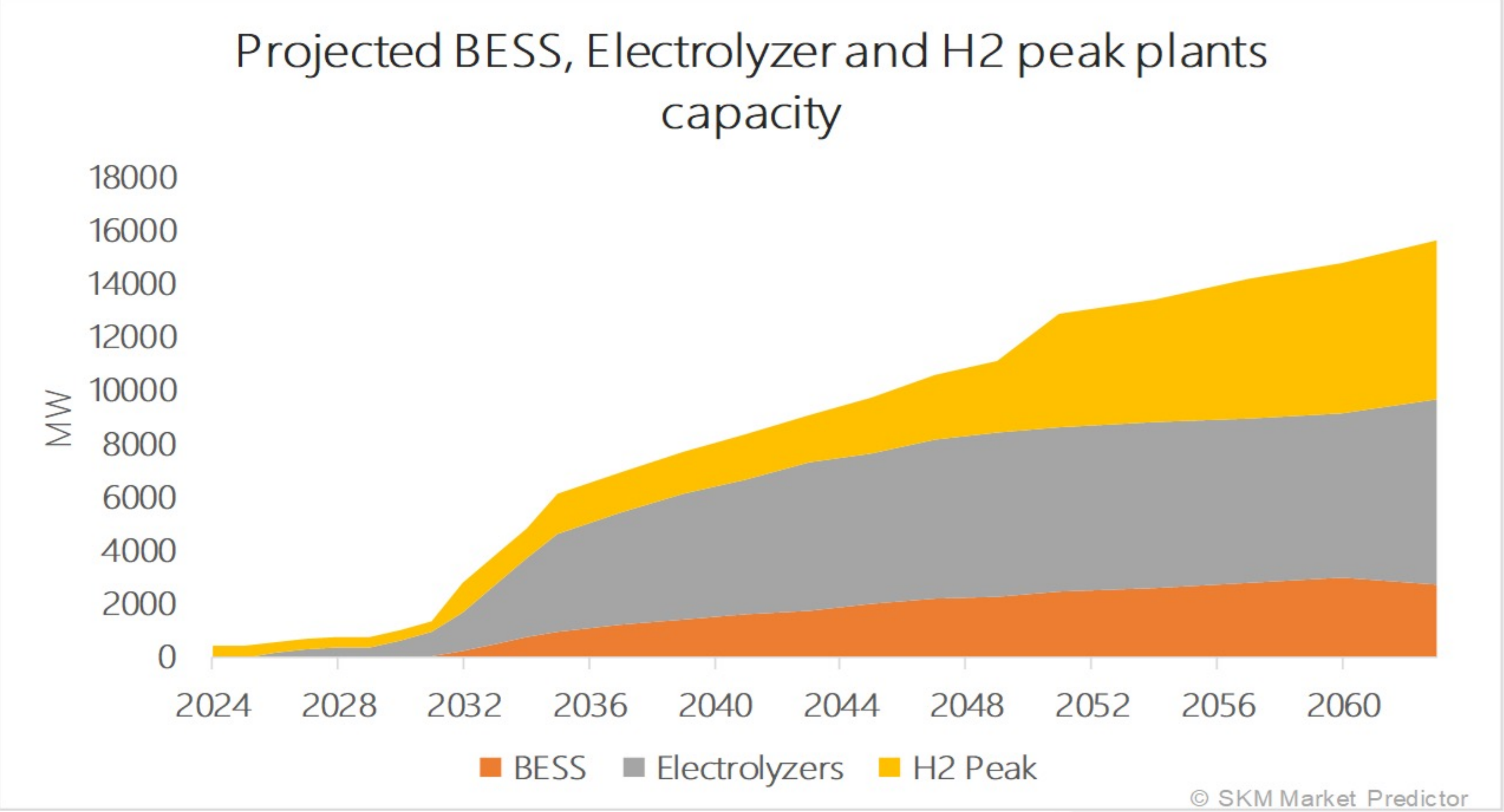




Offshore wind and flexibility requirements

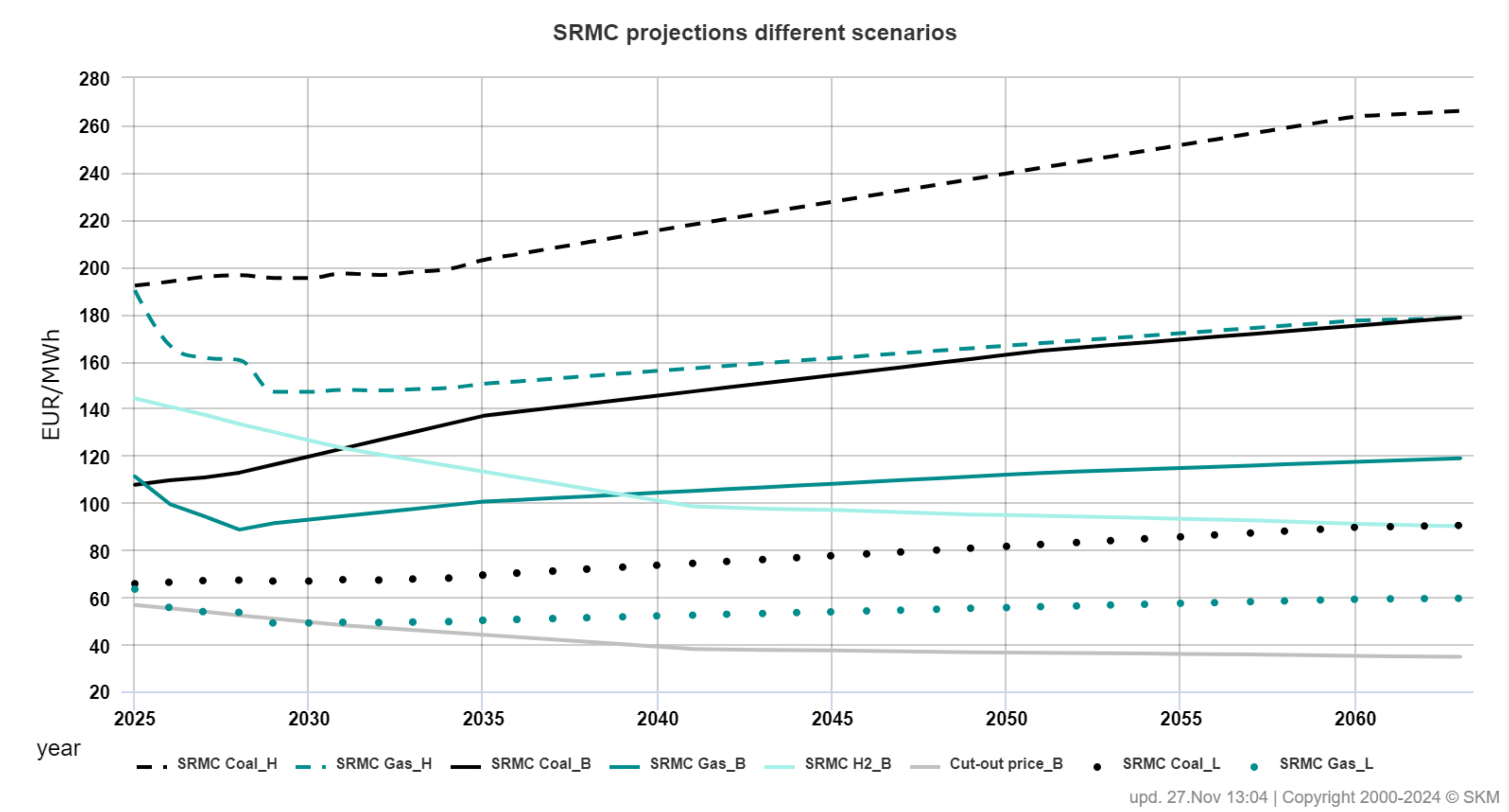
- In case more offshore wind is entering market volatility and capture rate decline will be increasing, however this is depedent on the:
    - Strong decline in the LCOE of offshore wind
    - Strong decline in the LCOH of electrolyzers and sufficent price of green hydrogen in the market
    - Enouth flexible sources to balance power system
- Volatility will also increase substancial and will requere significant amounts of flexible sources in form of optimized electrolyzes and BESS
- New generation based on the utilization of the green H2 is needed to help balancing renewables during low production
- By 2045 following flexible capacity are at least required in the Finnish power system :
    - 1 GW BESS
    - 3.5 GW of electrolyzes operated in the flexible mode
    - 1.5 GW of hydrogen peak power stations

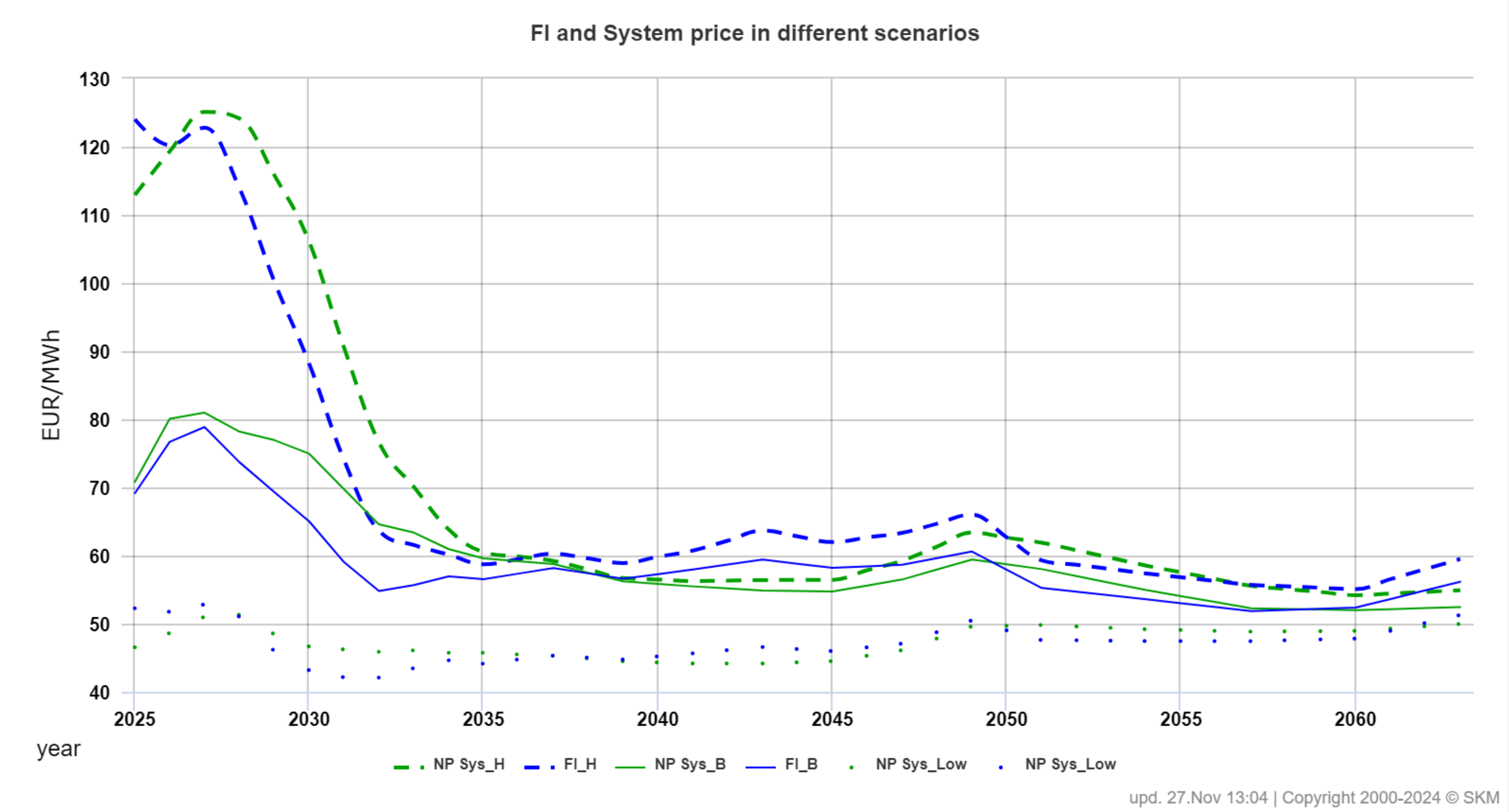




Price development sensitivities

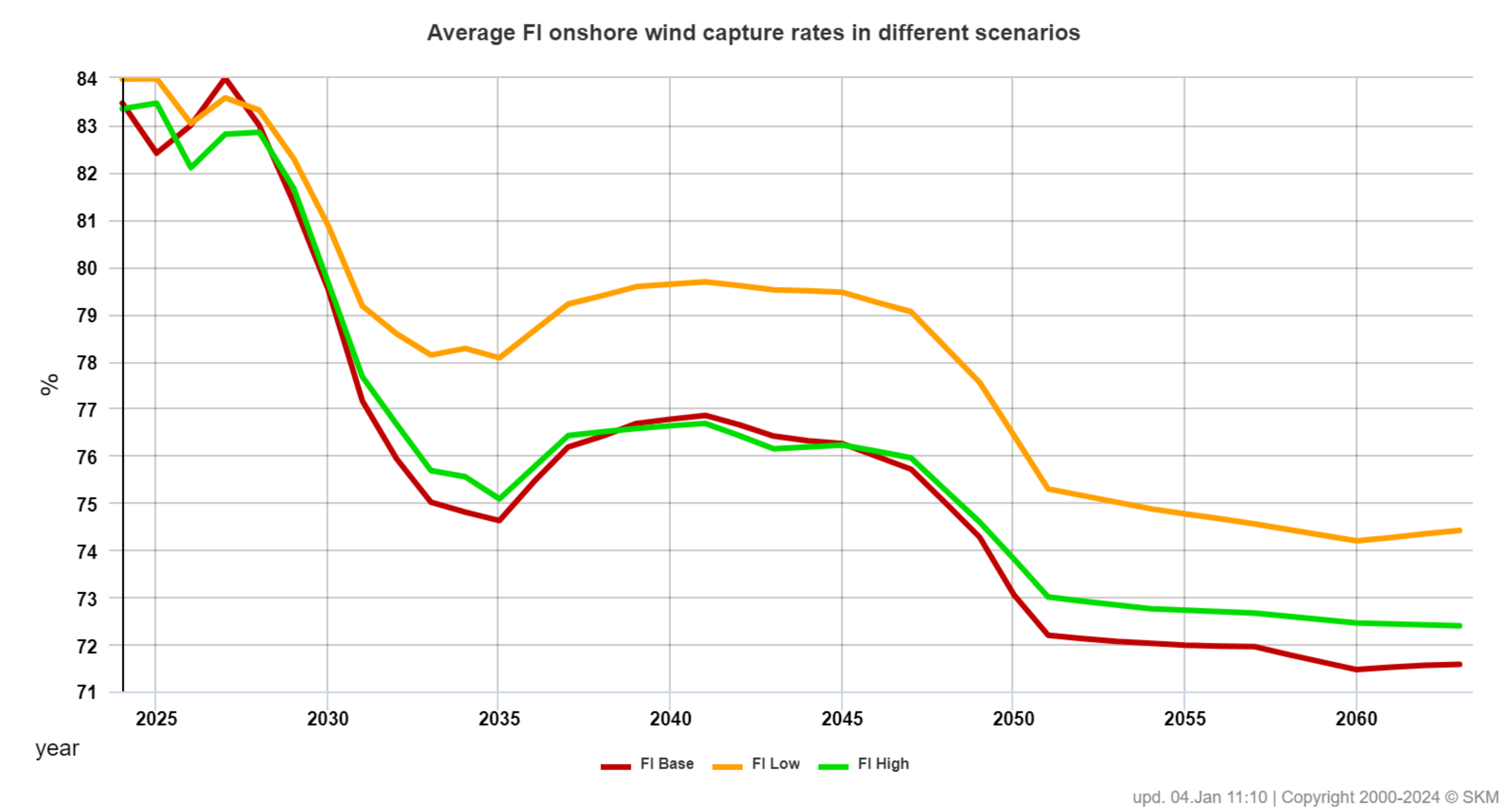
- Until 2030-2035, carbon and thermal price will still have the major impact on the power price development through SRMC costs of the remaining thermal generation
- Our sensitivity scenarios assume 30% decrease/increase of thermal SRMC costs which is similar levels observed during Covid19 and August-September 2022 energy crisis
- Strong SRMC changes lead to radical impact on Finish power price development and might provide «wrong» signals to investors
- Increased commodity price level will improve RES profitability and lead to further growth, however initiating sharp price decline afterwords
- Lower power price level will have major impact on the offshore wind construction, making it unprofitable and reducing penetration of H2.
- Extending lifetime of the current nuclear fleet or construction of SMR will be challenging with lower prices, resulting in significant reduction of nuclear production 2040s
- From 2035, the H2 price will be the main decisive factor for power price settlement and renewable construction, however the uncertainty is very large even for the base scenario due to unknow development of the LHCO and offshore LCOE costs and hydrogen price

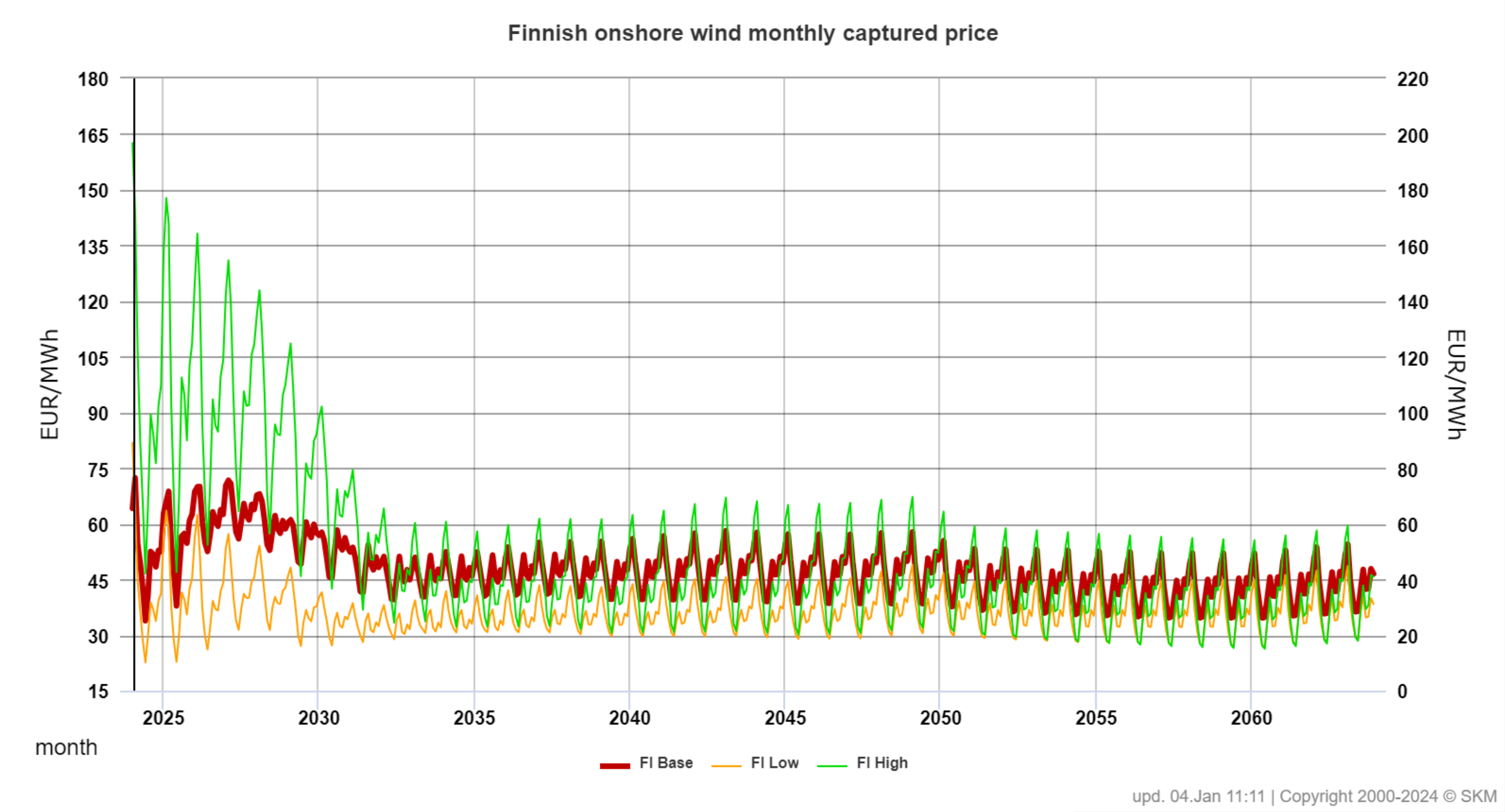




Capture rates and wind captured price development

- LCOE of renewable generation and captured price level determinative for the capacity and location of new RES projects
- The future capture rate risk will be limited by the technological development of energy storage technologies and demand flexibility
- The expected strong increase of new wind generation in Finland will result in a rather stronger decline in the capture rates towards 2035 and will also demand construction of H2 in the Base scenario
- Power prices, and as a result power balance development, will have direct impact on the capture rates and captured price in sensitivities scenarios
- Higher prices will trigger more offshore wind and H2 construction but will lead to rather strong decline in wind capture rates and even higher CR and captured price volatility
- Lower prices will slow down renewable construction and allow to sustain CR and captured prices at higher and rather stable level





Other uncertainties

- Final outfall of European strategy to reduce dependency on Russian energy and transfer to carbon neutral power system
- Political commitment for decarbonization and increase of renewable capacity
- General economic development and growth
- Rate of decline in the RES investment costs
- Development of required flexible capacities across all areas to facilitate renewable growth
- Phase-out of remaining thermal capacity and construction of additional flexibility generation utilizing green hydrogen
- Development of the new and extending lifetime of existing nuclear capacity. Based on the power balance consideration, at least one more nuclear unit is required in Finland, which we assume will come around 2040.
- Cost development for green hydrogen production and utilization as the main driver for prices after 2035
- Speed of green hydrogen technology penetration across power markets on both the demand and power generation sides.
- Consumption growth, rate of electrification and electrolyzes consumption
- Reinforcement of internal transmission capacities and construction of the new interconnectors abroad
- Global climate changes
- Hydrological situation as the major source of volatility for the in a shorter perspective

SKM Market Predictor – leading provider of analysis and advisory services for power and renewable markets

SYSPOWER	Long Term Power Outlook	Profitability of RES production	Risk report	Advisory

SYSPOWER

Web tool – data, forecasts and analysis on power markets

- Short, mid and long-term power forecasts
- Coverage of commodities and CO_2 markets
- Extensive weather data
- Detailed UMM information
- Advanced data warehouse solution with easy data extraction possibilities
- Advanced BI solution for own analysis construction

Long Term Power Outlook

Nordic/Baltic and European power forecast for up to 40 years

- Quarterly updated 40 years ahead power forecasts
- All input assumptions and results are available through SYSPOWER dataware house
- Constantly updated EMPS model though weekly and quarterly updates
- Possibility for scenarios runs

Profitability of RES production

Standard and tailor-made calculations

- Monthly/quarterly/annual capture rates for solar, on/offshore wind for each Nordic/Baltic price area
- Delivered as part of LTPO, or Nordic risk report
- Models for estimations of solar/BESS profitability
- Models to estimate H2 profitability

Risk report

PPA analysis and area-specific report

- Evaluation on market and price risks of Nordic and Baltic price area
- Overview and analysis of the PPA market in Nordics/Baltics
- Detailed country specific reports which can be tailored for client needs

Advisory

Various advisory projects

- Investment analysis
- Arbitrage assistance
- PPA advisory and evaluation
- Risk management and policy
- Proven record of successful participation in many financial transactions

All questions are welcomed!

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Levelized costs of renewables

- Onshore and offshore wind power is cheaper in the Nordic countries compared to global estimates and neighboring countries due to higher wind factor and possibility to construct offshore wind power due to the long coastline
- With the overall good wind conditions in the Nordic countries onshore wind does not need to be subsidized particularly in the southern price areas.
- The biggest decline in LCOE is expected for offshore wind due to strong expected construction of this technology in the future
- LCOE for solar power has decreased strongly based on the global data, especially in the southern latitudes
- Nordics with lower amount of full load hours had limited competitiveness of solar power production until recently, however, anticipated cost decline brings solar in the competitive position
- The main drivers for renewable power's cost reduction are improvements in technology, competitive procurement, and a large base of experienced, internationally active project developers.
- During 2022-2023 supply-chain woes pushed up the cost of new-build solar, battery storage and onshore wind.
- Recently increased cost of financing contributed to LCOE rise

LCOE estimates	Solar PV		Onshore wind		Offshore wind	
	Low (5%)	Average	Low (5%)	Average	Low (5%)	Average
Lazard (Global estimates 2023)	24	30	24	44	58	95
IRENA (Renewable power generation costs 2021)	24	33	23	33	47	71
Bloomberg New Energy Finance (Global estimates 2022)		33		35		78
Statnett long-term report (Nordics)		48		33		51
Danish Energy Agency (Denmark)		33		30		49
Pexarpark (Germany)		36		31		

Green hydrogen costs

- The EU goal is to move toward low-carbon hydrogen systems are an important steppingstone to support hydrogen ecosystems and ensure that green hydrogen will have a large enough marketplace
- The CAPEX of new electrolyzer production represents a rather significant cost for expected to gradually decline once the hydrogen technology becomes more mature, leading to a decline in the costs of produced hydrogen
- Bloomberg estimates that the CAPEX of electrolyzers will be reduced up to 70 % in 2030 and 90 % by 2050 in Europe. Hydrogen strategy for climate neutral Europe expects electrolyzers' prices to halve in 2030. This seems to be overoptimistic
- Green hydrogen have also to compete with other hydrogen types, in particular with «grey» hydrogen produced from the natural gas
- There is inherent uncertainty estimating the current and future costs of hydrogen production and green hydrogen price, particularly given that certain technologies do not yet exist at scale or have not yet been demonstrated.

	Alkaline		PEM		SOE	
	2023-30	2031-35	2023-25	2031-35	2023-25	2030-35
Nominal capacity, MW	100	100	100	100	100	100
CAPEX, EUR/Mw	869 565	521 739	1 043 478	521 739	1 739 130	782 609
Construction period, years	3	3	3	3	3	3
OPEX, % of CAPEX	2 %	2 %	2 %	2 %	2 %	2 %
Stack replacement, % of CAPEX	25 %	25 %	20 %	20 %	20 %	20 %
Stack lifetime, years	8	11	6	8	6	8
System lifetime, years	20	20	20	20	20	20
System efficiency LHV, %	65 %	67 %	61 %	66 %	70 %	73 %
Electricity consumption, kWh/kg H2	51,22	49,83	54,56	50,54	47,57	45,62
Capacity factor	80 %	80 %	80 %	80 %	80 %	80 %
Hydrogen costs EUR/ton	3,01	2,68	3,38	3,03	3,45	2,65
Hydrogen costs without CAPEX	2,37	2,04	2,52	2,17	2,20	2,01