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How firm and flexible capacity supports Finland to become a green superpower

Capacity market options for Finland

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WÄRTSILÄ AND AFRY MANAGEMENT CONSULTING

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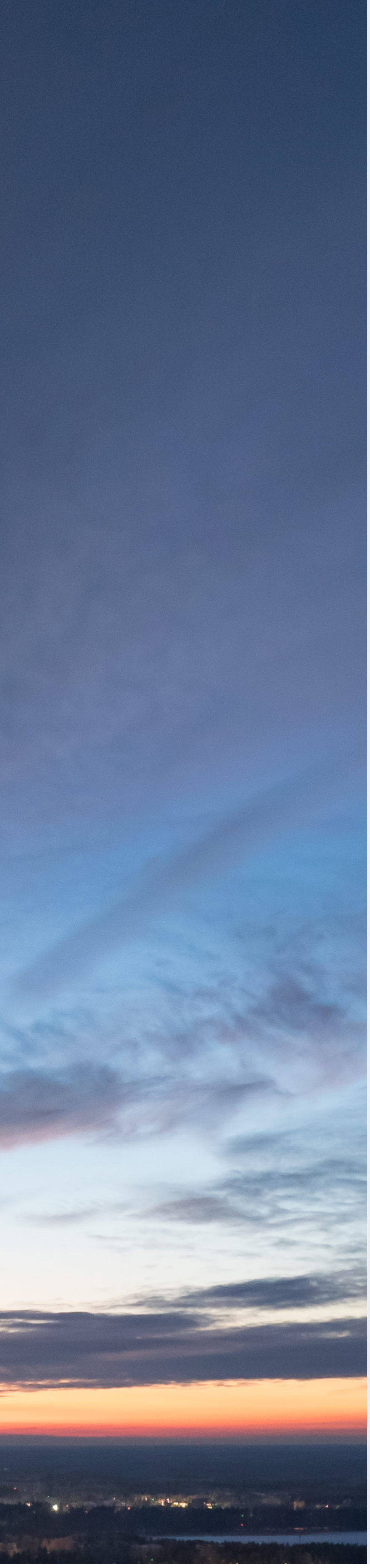

Foreword

Finland has an ambitious vision to become a 'green' powerhouse, attracting new industries, such as data centres and hydrogen production facilities. This means additional electricity demand, met predominantly by wind generation. Simultaneously, firm capacity will gradually reduce in the Finnish power system as older thermal units retire. However, firm and flexible capacity is still needed to cover for wind when weather conditions are unfavourable, particularly during extended cold and low-wind periods.

Fingrid has already identified the potential resource adequacy challenges in its Assessment of future capacity solutions to ensure resource adequacy in the Finnish electricity market -analysis. Similar issues have also been flagged in other Nordic countries. Wärtsilä's own analysis confirms these findings – generation adequacy may become a problem in the medium term, and firm capacity can help guarantee secure system operation.

An energy-only market may be unable to deliver investments in firm and flexible capacity as these assets operate infrequently and face significant price and volume risk. A capacity market can complement the energy-only market and (a) help ensure resource adequacy, (b) address the 'missing money' problem, and (c) act as a hedging instrument for capacity providers.

This report aims to highlight the need for a capacity market, assess different capacity market design options, recommend the most appropriate design for Finland, and propose considerations about capacity capabilities.

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Summary

There are broader economic benefits in attracting new industries and pushing ahead with decarbonisation. However, this energy transition challenges the Finnish resource adequacy during 'difficult' weather years. A difficult weather year in the Finnish context means a year with days to weeks of simultaneous high demand and low output from wind power. The power deficit during these difficult weather years can't be covered by energy storage, demand side response, or imports. Thus, new firm and flexible capacity is needed to ensure resource adequacy in the future.

Finland has an energy-only market which is in theory supported by a strategic reserve. However, power plants within the scheme cannot participate in the electricity market leading to stranded assets and its 12-hour start time requirement makes strategic reserve unsuitable for any kind of renewable balancing. Existing market design has had significant success in supporting secure system operation and new investments, mostly in wind, while some of the existing thermal units will gradually retire and the system becomes more weather-dependent. Growing electricity demand and increasing share of intermittent wind leads to a situation where firm and flexible capacity is needed during windless periods. Aforementioned firm and flexible capacity is, however, expected to operate infrequently. This entails price and volume risk and thus, the business case for such investments is challenging solely based on merchant market operation.

If the market signals do not incentivise investments in the new firm and flexible capacity, which can cover relatively infrequent challenging weather periods, how can Finland ensure resource adequacy going forward? Similar concerns about resource adequacy have led to the introduction (or plans to introduce) capacity mechanisms during this and the last decade in many of the EU Member States including three of its largest economies: Germany, France and Italy.

Implementing a capacity mechanism comes with a cost, which the end users eventually pay. However, its introduction delivers the following societal benefits: increased reliability, enhanced security of supply, a potential reduction in wholesale electricity market prices, and less year-on-year price volatility. Design choices should be considered carefully to ensure that the possible capacity mechanism solves the Finland-specific system adequacy challenge.

Finland needs to act swiftly. Simulation suggests that resource adequacy will become an issue towards the end of this decade. Based on the experience in other European markets, designing and implementing a capacity mechanism can take many years. The first steps for introducing a capacity mechanism must be taken as soon as possible.

Electricity demand will rise sharply with widespread electrification and new industries – the system will become 'tight' over cold and low-wind periods

WHILE ELECTRICITY DEMAND INCREASES THERE IS SIMULTANEOUS DECREASE IN FIRM PRODUCTION CAPACITY

Industries, such as metals and forestry, need to reduce their carbon footprint and switch to alternative fuels. Electrifying existing processes appears to be an obvious choice. At the same time, the transport sector is already undergoing a rapid transformation with EVs having become the mainstream solution. Electrification, coupled with the power demand for hydrogen production and other new green industrial investments that Finland aims to attract, means that overall power demand is expected to increase despite energy efficiency measures.

Going forward, some of the power demand will be more flexible responding to the underlying availability of affordable power production resources and system needs. However, this will take time and there will still be a baseline level of demand that cannot be shifted or curtailed. According to Fingrid's estimates, electricity demand will be some 130 TWh in 2030[1].

Finland wants to become carbon neutral by 2035[2], and most industrial players will also have their own decarbonisation pathways. This means weather-dependent renewable production capacity, particularly wind, will continue to be added to the system.

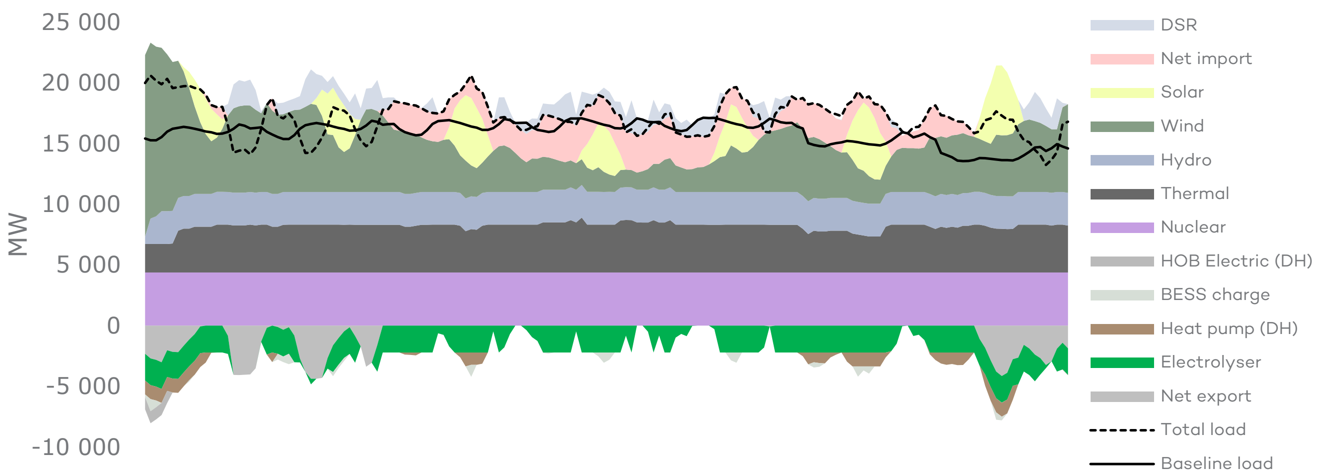
According to Fingrid's projections, in 2030 there would be 21 GW of wind power and 9 GW of solar power in the Finnish energy system[1]. At the same time, some of the existing thermal capacity is retiring in response to unfavourable economics and decarbonisation targets.

The amount of demand side response (DSR) is also expected to increase significantly. The assumed available DSR capacity is 3.5 GW by 2030 in this study. DSR is used to cover short-time supply and demand mismatch. However, even with generous DSR assumptions, firm and flexible capacity is still needed to cover for wind when weather conditions are unfavourable.

Figure 1 below presents the Finnish power balance during an example week in February 2030 during a normal weather year. As seen in the figure, electricity imports play a crucial role during high-demand and low-wind days. Baseline load represents the load excluding electric boilers and electrolysers, before any DSR activation and excluding exports. Total load represents the load including electric boilers and electrolysers, after any DSR activation and excluding exports.

All figures and results presented in this paper are based on simulations made on Wärtsilä's fundamental power system model[3].

FIGURE 1. Finnish power balance during an example week in February 2030 in average weather conditions



1 Sähkön tuotannon ja kulutuksen kehitysnäkymät- Fingridin ennuste Q1/2024
2 The Finnish Climate Act (423/2022)
3 Model contains all interconnectors relevant to the Finnish market. Model runs on an hourly resolution which is essential to capture the dynamics of reliability and price formation. The model uses the future projections following the ENTSO-E European Resource Adequacy Assessment (ERAA) 2022 assessment. ENTSO-E is the European Network of Transmission System Operators for Electricity. ENTSO-E publishes yearly the ERAA, which is a pan-European monitoring assessment of power system resource adequacy of up to 10 years ahead.

RESOURCE ADEQUACY HAS HISTORICALLY BEEN ON AN ACCEPTABLE LEVEL IN FINLAND

Finnish resource adequacy has been on an acceptable level thanks to, e.g., significant hydropower capacity balancing the system and the recent commissioning of OL3. Prior to 2022, electricity imports from Russia were also a significant source of electricity, especially on cold winter days; in aggregate imports from Russia have been replaced largely by imports from Sweden and additional generation in Finland (mostly wind and nuclear).

CHALLENGES START TO OCCUR DURING THE MOST DIFFICULT WEATHER YEARS

In this study, Wärtsilä has simulated the Finnish power system in 35 different weather years to estimate the number of hours in a year when resources are insufficient to meet demand. This number is commonly known as LoLE, Loss of Load Expectation. LoLE results, presented on the next pages, are at acceptable levels considering the average of the 35 weather years simulated.

However, challenges start to occur when simulating the most difficult weather years: the weather patterns during the three worst weather years cause an unacceptable power deficit in the system.

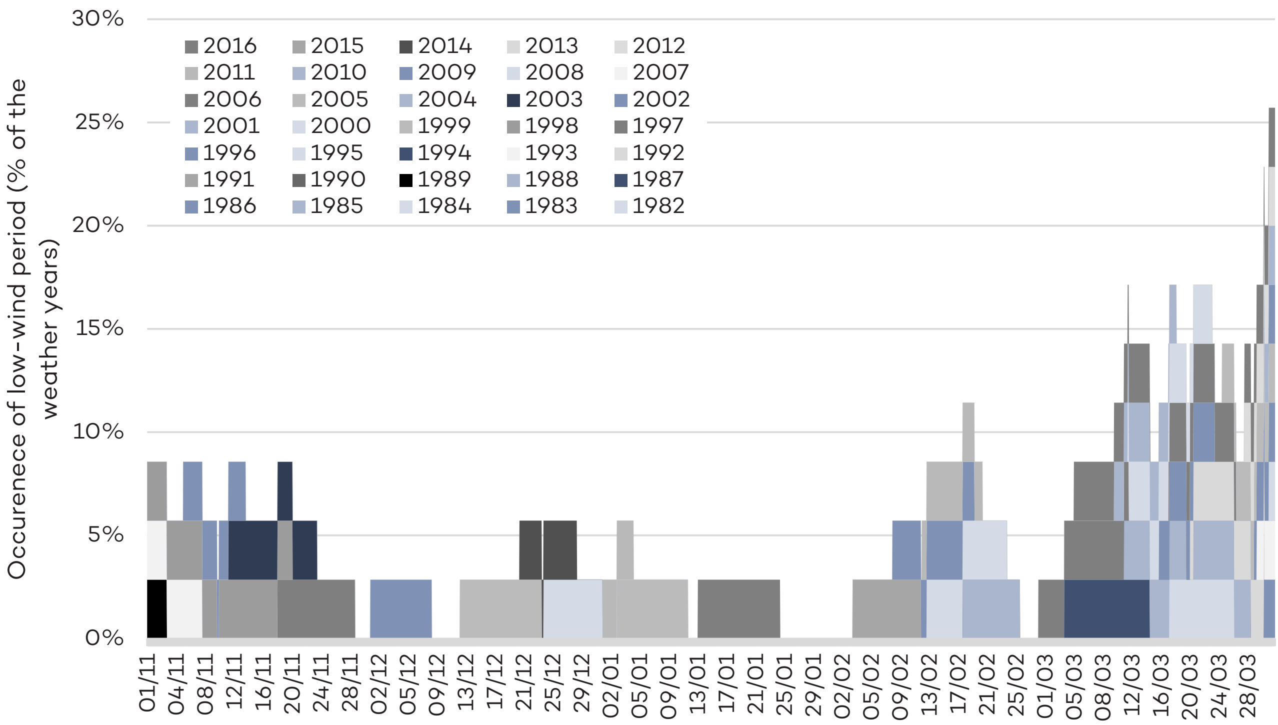
Even though difficult weather years are relatively rare (three out of 35), they cause severe resource adequacy challenges. Over such periods, resource adequacy can only be achieved with resources that have very long duration or no energy limitations, i.e. firm and flexible capacity.

HISTORICALLY, WEEK-LONG OR LONGER LOW-WIND PERIODS OCCUR ONCE EVERY YEAR DURING COLDER MONTHS

The frequency of low-wind periods in Finland was estimated based on historical data. Figure 2 presents all the week-long or longer low-wind periods during the colder months (November-March) from 1982 to 2016. Each block in Figure 2 represents one such period, and the wider the block, the longer the period. Low-wind periods occurring at the same time in different years are stacked. An example to help interpret the figure: the probability of a week-long or longer cold period during the first week of November is ~8%.

Historically, a week-long or longer low-wind period during colder months occurs once every year. Once in ten years low-wind periods coincide with high-demand, causing a resource adequacy challenge to the Finnish power system.

FIGURE 2. Probability of week-long or longer low-wind periods during winter months (November-March) in Finland based on historical weather data from years 1982-2016



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New firm and flexible capacity is needed alongside energy-limited units, like storage and demand side response, to ensure the security of supply in the future

THE WORST THREE WEATHER YEARS RESULT LOLE VALUES THAT EXCEED THE THRESHOLD

According to Wärtsilä's modelling, the LoLE is at an acceptable level with average weather conditions both in 2027 and 2030, as shown in Table 1. Modelling by Fingrid and ENTSO-E also confirms that system reliability is sufficient at the end of the decade, albeit with a tighter margin. According to ENTSO-E, LoLE value for 2025 is above the threshold of 2.1 hours which means that the required system adequacy is not met.

The impact of a difficult weather year as well as Olkiluoto 3 outage and Fennoskan outage were analysed, in addition to the average weather year with no major outages.

Both Wärtsilä's and Fingrid's results show that during a difficult weather year (once in ten years) in 2030 the LOLE threshold of 2.1 hours is not met. In the case of an outage of Olkiluoto 3 (or any other event causing a reduction in dispatchable capacity of 1.6 GW) from the Finnish energy system, LoLE increases far above 2.1 hours both in 2027 and in 2030. Challenges caused by an outage of Fennoskan are almost equally severe.

ENERGY-LIMITED SOLUTIONS ARE NOT ENOUGH TO ENSURE SECURE SYSTEM OPERATION AND DELIVER AFFORDABLE ELECTRICITY – FIRM AND FLEXIBLE CAPACITY IS NEEDED

Prolonged cold spells of days to weeks with limited wind availability (Dunkelflaute) cannot be managed effectively with energy-limited solutions. The risk of blackouts increase without the right type of resources in the system. This also has a significant impact on the cost to consumers as prices rise to very high levels in periods of extreme scarcity.

Additional simulations were conducted to evaluate the impact of additional firm and flexible capacity. The results with additional 1 GW and 2 GW of capacity are presented in Table 2 on the next page.

WHAT DO WE CONSIDER AS FIRM AND FLEXIBLE CAPACITY?

A resource is flexible if it can adapt swiftly to underlying conditions with short start and shut-down times, no start costs and have limited technical restrictions (such as no minimum up and down times and low minimum stable load)

A resource is firm if it can be started up whenever necessary and operated as long as required under all weather conditions

TABLE 1. WÄRTSILÄ SIMULATION RESULTS OF FINNISH POWER SYSTEM LOLE COMPARED TO FINGRID AND ENTSO-E

	WÄRTSILÄ		FINGRID[3]		ENTSO-E ERAA (2023)[4]		
SCENARIO	2027	2030	2027	2030	2025	2028	2030
Average weather conditions							
Forecast	0.1	0.4	0	1.9	4.1	2.1	1.7
Olkiluoto 3 outage	2.3	2.5	9	29			
Fennoskan outage	1.9	2.0	4.2	20			
Worst three weather years							
Forecast	1.7	5	0	19			
Olkiluoto 3 outage	21	22	39	149			
Fennoskan outage	21	20	21	117			

Acceptable LoLE (≤2.1 hours)

LoLE is too high (>2.1 hours)

3 Assessment of future capacity solutions to ensure resource adequacy in the Finnish electricity market 2023
4 Entso-E ERAA 2023

New firm and flexible capacity is needed alongside energy-limited units, like storage and demand side response, to ensure the security of supply in the future (cont'd)

TABLE 2. NEW FIRM AND FLEXIBLE CAPACITY ADDITIONS REDUCE LOLE VALUES DURING WORST THREE WEATHER YEARS

Acceptable LoLE (≤2.1 hours)
LoLE is too high (>2.1 hours)

		2027			2030		
SCENARIO	ADDED CAPACITY	0 GW	1 GW	2 GW	0 GW	1 GW	2 GW
Forecast		1.7	0	0	5	0	0
Olkiluoto 3 outage		21	7	0	22	6.7	0
Fennoskan outage		20	7.7	0	19	6.7	0

FIRM AND FLEXIBLE CAPACITY CAN ENHANCE RESOURCE ADEQUACY AND PROTECT CONSUMERS

The addition of firm and flexible capacity, with its proven reliability, can help to ensure resource adequacy during the years of difficult weather patterns. Adding just 1 GW of new firm and flexible capacity can completely remove the expected loss of load during a difficult weather year. With 2 GW of firm capacity, the Finnish system appears to be adequate even in the most extreme and unlikely scenario, combining cold and low wind output together with an outage of some critical electricity infrastructure.

The resource adequacy challenge has led to many European countries introducing capacity mechanisms. The need for a capacity mechanism has often emerged from the retirement of conventional capacity, such as gas and coal, combined with a significant growth of renewable energy production. During the last decade, capacity mechanisms have been introduced in multiple European countries, e.g. Belgium, France, Germany, Great Britain, Ireland and Italy. Of particular note, the Swedish TSO is proposing a capacity mechanism to ensure resource adequacy.

ADDING NEW FIRM AND FLEXIBLE CAPACITY WOULD DECREASE THE AVERAGE SYSTEM PRICE - THE INVESTMENT ENVIRONMENT WOULD ALSO BE MORE SUPPORTIVE OF NEW LOW-EMISSION INDUSTRIAL INVESTMENTS

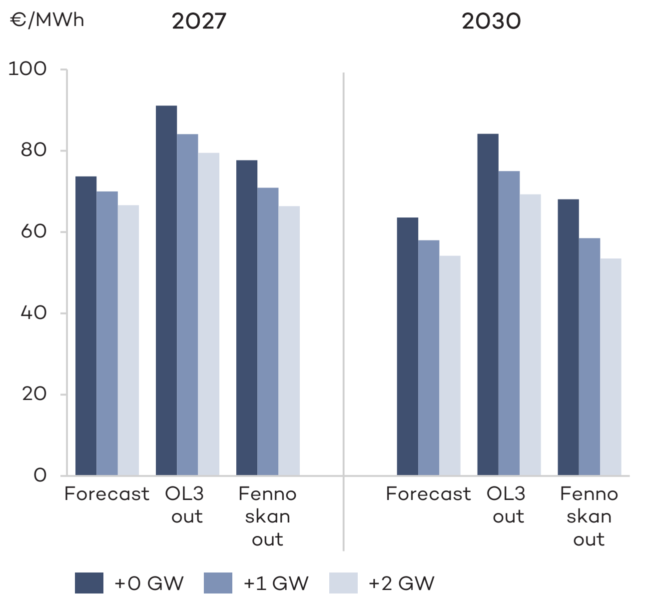
Adding new firm and flexible capacity results in lower wholesale prices, as shown in Figure 3. There is more available capacity at times of system 'tightness', which helps to keep electricity prices at lower levels during the times of high pricing.

Based on the Wartsila modelling, adding 1 GW or 2 GW of new firm and flexible capacity brings annual wholesale electricity cost to Finnish consumers down by 0.7 or 1.3 billion euros, respectively.

However, it should be noted that a capacity mechanism comes with a cost which the end users will ultimately pay. Thus, a capacity mechanism would increase the fixed component and reduce the variable component of the electricity bill. For a full comparison an impact assessment should be done including total system costs, consumer and producer surpluses and revenue distributions (e.g. lower wholesale prices mean lower revenues for some generators).

Plenty of new industrial investments are planned for Finland, which would require large amounts of electricity. The consumption linked to these green investments would benefit from increased system reliability, price predictability and lower system prices.

FIGURE 3. Average yearly area prices, average of 35 weather years, with 1 GW and 2 GW of new firm and flexible capacity during years 2027 and 2030



WÄRTSILÄ AFRY

New firm and flexible capacity is needed alongside energy-limited units, like storage and demand side response, to ensure the security of supply in the future (cont'd)

MISSING MONEY REPRESENTS THE MISSING REVENUE TO SUPPORT THE BUSINESS CASE FOR FIRM AND FLEXIBLE CAPACITY

The business case for new firm and flexible capacity is missing. Since extreme weather conditions are rare, 'backup' firm and flexible capacity is expected to operate infrequently, leading to price and volume risk. This makes the business case for such investments challenging solely based on merchant market operation. At the same time, modelling results clearly show that this type of capacity is needed. To address this, it's crucial to introduce hedging instruments and/or separate markets that reward availability and capability, thereby facilitating investments in such provision.

Expected low revenues and uncertain upsides result in the new firm and flexible investments appearing unattractive to investors. This is the missing money problem - when the energy-only market provides insufficient price signals to attract investments in supply security.

Addressing the challenge of the missing money problem requires specific technologies. In this study, we have evaluated and presented the technologies that can provide firm capacity with a minimum duration of a week (Table 3) . To estimate the amount of missing money, we added 1 GW of each capacity to Wärtsilä's model. The missing money is the difference between the expected revenues of this additional capacity and the revenues needed to reach the hurdle rate investors require.

THERE IS MISSING MONEY FOR ALL FIRM TECHNOLOGIES EVALUATED – A CAPACITY MECHANISM WOULD SUPPORT THE INVESTMENTS

Missing money results are presented in Table 3. There seems to be missing money for all technologies evaluated. Introducing a capacity mechanism could tackle the missing money challenge as capacity payments would provide an additional revenue stream for the investors. With the additional revenue stream, the required hurdle rate is reached, and investments would be attractive for investors. Many European countries have adopted capacity markets to address the resource adequacy and missing money problem, including Belgium, France, Great Britain, Ireland and Italy.

As a benchmark, recent capacity market auction clearance prices in Ireland and Great Britain (T-4 auctions, delivery year 2027/2028) were £100 000 /MW/year[5] (106 667 EUR) and £65 000 /MW/year[6] (76 000 EUR), respectively. It should be noted that capacity payments need to be financed. Financing can happen via tariffs or charges which will ultimately mean additional payment for the consumers. In contrast, a capacity mechanism will lower the price of wholesale electricity, reducing the total cost impact of implementing a capacity mechanism

TABLE 3. SELECTED TECHNOLOGIES' CAPABILITY AND MISSING MONEY ASSESSMENT (ASSUMPTIONS: 10% IRR REQUIREMENT, 10 YEARS CAPACITY CONTRACT AND 20 YEARS ECONOMIC LIFETIME FOR ALL TECHNOLOGIES)

TECHNOLOGY	Duration of supply	Response time[7]	Time to market[8]	Carbon emissions[9]	Missing money (EUR/MW/a)
Gas engine	Up to weeks	2-5 minutes	Short	Medium	71 000
Gas engine (CHP)	Up to weeks	2-5 minutes	Short	Medium	140 000
Gas turbine	Up to weeks	10-20 minutes	Short	High	100 000
Gas turbine (CHP)	Up to weeks	10-20 minutes	Short	Medium	121 000
Biomass CHP	Baseload[10]	Hours	Long	Low	169 000
Nuclear	Baseload	Hours	Long	Low	551 000
Pumped hydro storage	Up to days	Minutes	Medium	Low	
Storage (BESS)	Up to hours	Seconds	Very short	Low	
Long-duration BESS	Up to days	Seconds	Medium	Low	
Demand side response	Up to hours	Seconds	Short	Low	

5 NationalgridESO T-4 Auction (Delivery Year: 2027-27) – Published Round Results
6 SEM Capacity market 2027/2028 T-4 Capacity Auction Final Capacity Auction Results
7 How fast technology can respond to the demand signals
8 Very short: <1 year, short: 1-3 years, medium: 4-5 years, long: >5 years
9 Low: no direct emissions, Medium: <500 g/kWh, High: >500 g/kWh
10 Only during the heating season

An energy-only market complemented by a capacity mechanism can help deliver the desired resource adequacy

DESIGN DETAILS OF A CAPACITY MECHANISM SHOULD BE CAREFULLY CONSIDERED

Design details of a capacity mechanism should be carefully considered. Design choices are presented below in the form of building blocks. The capacity mechanism design is complex, and the design phase can last several years.

ELIGIBILITY DEFINES WHICH CAPACITY CAN PARTICIPATE IN A CAPACITY MECHANISM

Eligibility refers to the criteria determining which technology is eligible to participate in a capacity mechanism and on what basis. Targeted mechanisms use specific measures to address adequacy issues and restrict eligibility to certain technologies, while market-wide mechanisms allow all technologies to participate. Other eligibility considerations include whether to include interconnection capacity in geographical boundaries and applying carbon emission thresholds. A fundamental decision is the choice between targeted and market-wide mechanisms.

Based on experience from other European markets so far, only strategic reserve has been an accepted form of a targeted capacity mechanism under European regulation.

CAPACITY REQUIREMENT AND RESPONSIBILITY DEFINE WHO IS RESPONSIBLE FOR SETTING AND PROCURING THE CAPACITY NEEDED

Another fundamental decision is who is responsible for setting and securing the system's capacity. Options are either centralised (typically the TSO, but it can be a different central organisation) or decentralised (electricity retailers and capacity producers) procurement.

Most countries that use capacity mechanisms have opted for centralised procurement. Centralised procurement is simpler to understand and implement, so considering the urgency, it might be a faster way forward for Finland to start implementing the country's first capacity mechanism. Even though decentralised procurement is uncommon, it can have significant benefits, most notably in the ability to reveal demand-side flexibility within a portfolio.

FIGURE 4. The building blocks of a capacity mechanism

A. PRODUCT DEFINITION

- **Product** – What is the nature of the capacity product?
- **Eligibility** – What capacity can participate and on what basis?
- **Duration** – What timeframe is attached to the capacity product?
- **Nature of obligation** – What obligations sit on capacity providers?
- **Nature of penalty** – What are the consequences of non-delivery?
- **Participation of capacity in wholesale market** – How does capacity covered by the CRM participate in the wholesale market?

B. PAYMENT RECOVERY

- **Recovery** – What is the basis for capacity payment recovery?

C. CAPACITY SETTING / SECURITY

- **Capacity requirement volume** – On what basis is the overall volume requirement set?
- **Responsibility for securing volume** – Who has responsibility for securing the required capacity?
- **Method of securing capacity** – What mechanism is used to secure capacity requirement?
- **Lead time** – What is the timeframe over which capacity is secured?

D. PRICE RELATED

- **Capacity price setting** – What is the mechanism for setting the capacity price?
- **Strike price setting** – If relevant, how is a strike price set?
- **Market reference price setting** – If relevant, what is the market reference price?
- **Utilisation price setting** – If relevant, how is utilisation price set?

An energy-only market complemented by a capacity mechanism can help deliver the desired resource adequacy

BOTH CENTRALISED VS DECENTRALISED AND TARGETED VS MARKET-WIDE OPTIONS WERE EVALUATED

The evaluation focused more on centralised than decentralised methods, because a centralised option may be easier to be accepted more widely initially. However, as familiarity increases in the capacity market, a decentralised solution could be possible.

We focus on market-wide solutions as they tend to endure and value all available capacities equally. The only exception is the non-fossil flexibility scheme, a targeted scheme the EU put forward in 2023. It could provide a faster, potential short-term solution for the emerging adequacy challenge. Creative solutions are needed for new firm and flexible capacity requirements in the Finnish system. All options should be be explored – non-fossil flexibility scheme could be a potential alternative.

FIGURE 5. CAPACITY MECHANISM OPTIONS CHOSEN TO BE EVALUATED IN THIS STUDY

1 AVAILABILITY PRODUCT (MARKET-WIDE CENTRALISED MECHANISM)

A centrally operated market-wide solution. Used e.g., in Great Britain and Poland. It is open to both existing and new assets.

- The system operator holds annual auctions to procure the required capacity, and successful capacity enters into availability contracts in exchange for a fixed remuneration for the duration of the agreement (from one year (existing capacity) to several years (new capacity))
- Capacity providers are then obliged to be available at times of stress events or face financial penalties

2 CENTRALISED RELIABILITY OPTIONS (ROS) (MARKET-WIDE CENTRALISED)

Centrally operated, more recent evaluation of market-wide mechanism. Used e.g., in Ireland and Italy. It is open to both existing and new assets.

- Like availability product, but capacity providers are obliged to pay back 'difference payments' whenever the wholesale price exceeds a certain Strike Price
- Upfront capacity payments may be higher given the foregone inframarginal rent above the Strike Price
- A low Strike Price may disincentivise technologies having a marginal cost above the strike price

3 NON-FOSSIL FLEXIBILITY (TARGETED MECHANISM)

A targeted support scheme EU put forward for non-fossil flexible assets. Targets only new investments.

- Member States can promote the participation of non-fossil flexibility by either introducing additional criteria or features in the design of capacity mechanisms or by applying separate flexibility support schemes consisting of payments for the available capacity of non-fossil flexibility
- Not implemented yet in any of the EU Member States, but can be a potentially faster way to solve the challenge compared to a market-wide mechanism
- Seems to be conceived for storage and demand side response, but other technologies not explicitly excluded

4 DECENTRALISED PRODUCT (MARKET WIDE MECHANISM)

Decentralised capacity mechanism option. Used in France. Utilises both existing and new assets.

- Electricity retailers are responsible for contracting enough capacity to meet their overall demand from capacity providers
- Buyer and seller can define the duration of the contract and the lead time of the capacity
- In France, capacity certificates are traded bilaterally and via dedicated auctions
- Decentralised capacity mechanisms tend to be more complex, which is why the centralised procurement is often chosen

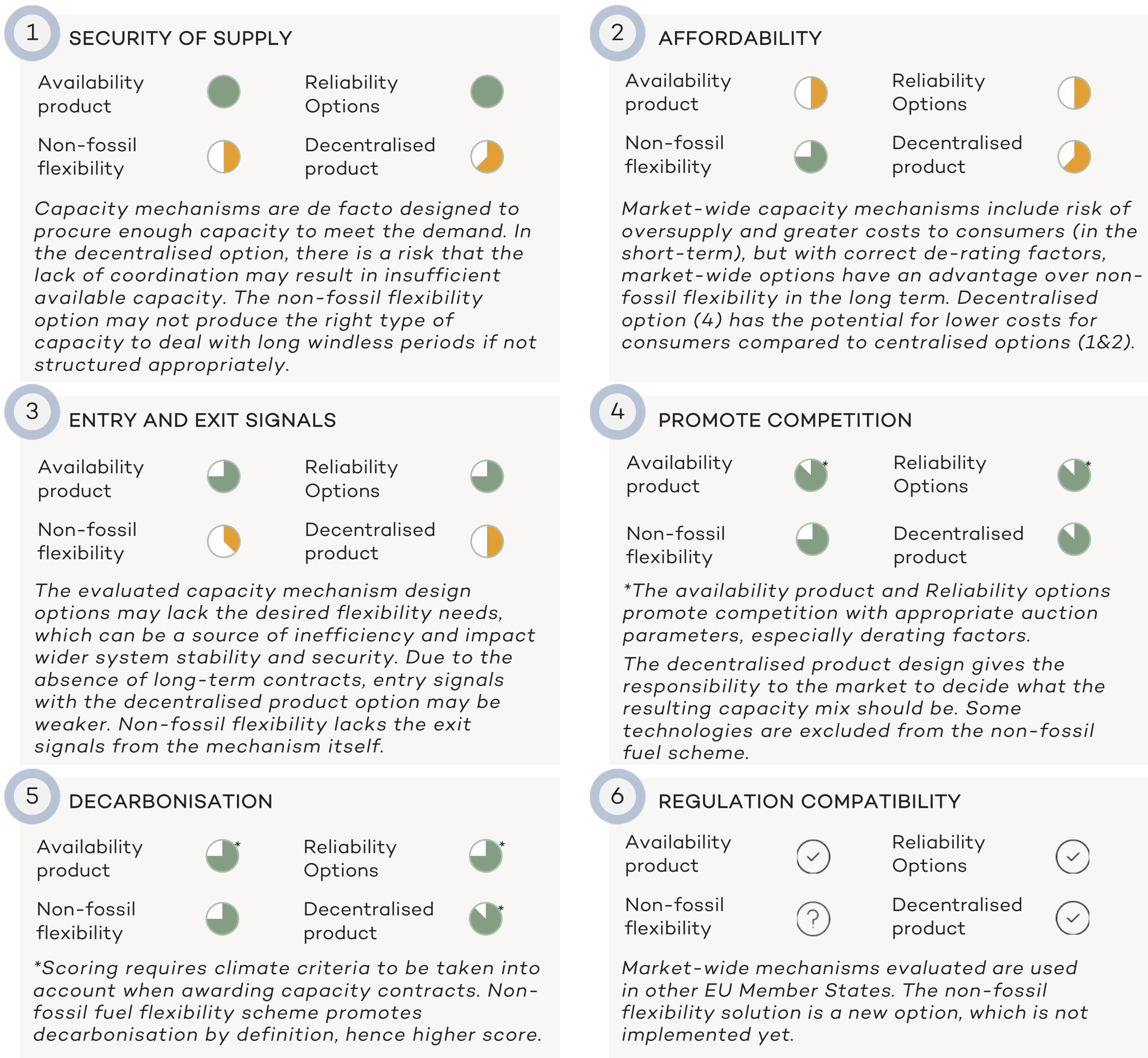
An energy-only market complemented by a capacity mechanism can help deliver the desired resource adequacy (cont'd)

THE SELECTED CAPACITY MECHANISM OPTIONS WERE EVALUATED WITH SIMPLE CRITERIA

The capacity mechanism options 1-4 presented in the previous page were evaluated in this study on a high level with the following criteria.

1. **Security of supply:** Does the solution solve the resource adequacy and flexibility concerns in Finland?
2. **Affordability:** What are the high-level procurement costs of the capacity mechanisms and cost impact on consumers?
3. Ability to deliver efficient **entry and exit signals for capacity**
4. **Promote competition** by minimising price distortions, and avoid contracting capacity that would've been active market-based
5. **Decarbonisation:** How effective is the mechanism in supporting Finnish climate and decarbonisation targets?
6. Evaluate if the proposed capacity mechanism is **compatible with Finnish and EU regulation**

FIGURE 6. High-level evaluation of the selected capacity mechanism options



The effectiveness of the capacity market depends on the detailed design parameters and implementation

CENTRALISED MARKET-WIDE OPTIONS APPEAR TO BE THE MOST APPROPRIATE SOLUTIONS FOR FINLAND IN THE CURRENT CIRCUMSTANCES

Our assessment suggests that the availability product and centralised reliability options can be more effective at ensuring the security of supply from the options evaluated. However, there is a risk of oversupply that can be managed with appropriate volume sizing.

THE DETAILED DESIGN OF THE DIFFERENT OPTIONS CAN SIGNIFICANTLY IMPACT PERFORMANCE AGAINST THE DIFFERENT ASSESSMENT CRITERIA

In the assessment, we concluded that the detailed design and the chosen parameters can heavily affect performance against the objectives – especially when it comes to promoting competition, decarbonisation and regulation compatibility.

De-rating factors are used in capacity mechanisms to reflect the ability of different capacities being able to contribute to capacity requirements during a system stress event. De-rating factors should be considered carefully to ensure that mechanisms promote competition and that the right capacity mix is procured. Typically, firm capacity receives higher de-rating factors (typically 80-95%) than intermittent renewables (wind typically 5-10% and solar 0-5%) and short-duration storage.

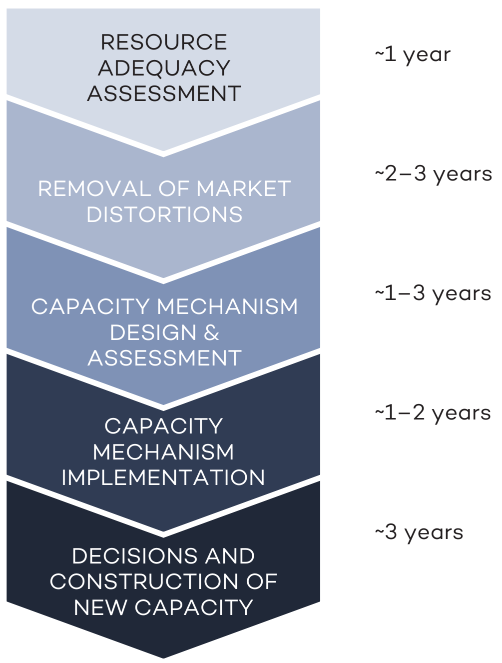
The non-fossil flexibility scheme (option 3) has not been implemented in any of the EU Member States yet. This mechanism still needs further investigation.

PROCESS AND TIMELINE OF A CAPACITY MECHANISM IMPLEMENTATION

As per European regulation, an energy-only market is the preferred option to ensure resource adequacy. When establishing a capacity mechanism, the first step is to identify if there is a potential adequacy problem. Should there be concerns, the first 'tool' to mitigate this is to explore if there are any market distortions and address those. Resource adequacy assessment is done yearly (e.g. ENTSO-E's ERAA) and market distortions are minimal in the Finnish system.

If removing market distortions is insufficient to ensure adequate resources, then a capacity mechanism can be adopted. The design and implementation of a capacity mechanism can take several years (from 2 to 5 years). Investment decisions in new capacity require secure revenue streams. Only after the revenue streams are secured, can the new power plants be constructed. Investment decision and the construction of new capacity takes approximately three years for most technologies. Therefore, the total time get new capacity on the market is in the best case five years from the start of capacity mechanism design as shown in Figure 7 below.

FIGURE 7. Capacity mechanism implementation process and estimated timeline



The scheme adopted should focus on procuring the right type of capabilities

IDEALLY, A CAPACITY MECHANISM SHOULD MOVE AWAY FROM THE SIMPLE AVAILABLE CAPACITY DEFINITION TO PROCURING THE RIGHT TYPE OF CAPABILITIES

Existing capacity mechanisms do not fully recognise that different capabilities have different values to the system.

A capacity mechanism should evolve towards an enhanced capacity mechanism. Currently, capacity mechanisms have some capability recognition, e.g. CO_2-emission thresholds and minimum notice period thresholds. However, these are still pass/fail criteria, and no recognition for enhanced capabilities exists.

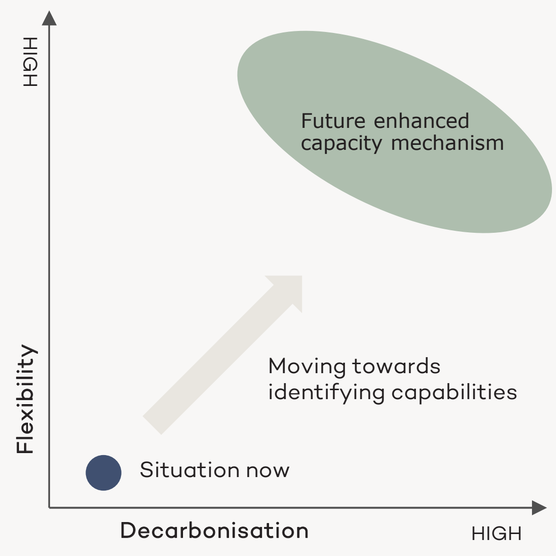
As power systems increasingly transition to low-carbon intermittent generation, the role of flexibility becomes paramount. An enhanced capacity mechanism can play a pivotal role in this transition, not only by directly recognising low-carbon generation but also by responding swiftly to significant weather-driven changes in generation, thereby ensuring the stability and reliability of the system.

ADDING A FLEXIBILITY ELEMENT TO A CAPACITY MECHANISM WOULD INCREASE BOTH THE MECHANISM'S ABILITY TO GUARANTEE THE SECURITY OF SUPPLY AND THE ABILITY TO DELIVER EFFICIENT ENTRY AND EXIT SIGNALS

The proposed enhanced capacity mechanism represents a novel approach, aiming to deliver both adequacy and flexibility in a single stroke. This innovative design could potentially outperform traditional availability product and reliability option mechanisms. Moreover, it could effectively address the need for flexibility and potential low-carbon constraints, thereby providing the necessary entry (or exit) signals to meet the capacity demands of a system of the future with high levels of RES penetration.

Such a mechanism has, however, not been tested in practice, requiring more time at the design stage and implementation. Given the circumstances, it may be better to start with a simple scheme and incrementally evolve it to an enhanced capacity mechanism.

FIGURE 8. The capability matrix and examples how to take the capability into account



HOW TO INCLUDE THE 'CAPABILITY' ASPECT TO A CAPACITY MECHANISM?

1. The simplest way: add pre-determined flexibility eligibility criteria to the purchased capacity. i.e. to be eligible, the capacity provider must ensure that capacity can respond within 1 hour
2. Segmentation based on the response time. For example, 1/3 of the procured capacity should respond within 5 minutes, 1/3 within one hour and 1/3 within three hours
3. Have multipliers or deflators in the prices based on the hours to respond. i.e., the longer it takes to respond, the lower the price

The time to act is now and the chosen capacity mechanism should be future-proof

CONCLUSION 1: THE DESIGN OF A CAPACITY MECHANISM SHOULD START IMMEDIATELY

The proper design and subsequent implementation of a capacity mechanism will require considerable time, typically several years. Investment decisions for new, reliable, and flexible capacity can only be made once the capacity mechanism is in place and the relevant construction begins. The construction phase itself also takes time. In total, it will likely take more than five years before the new capacity is commissioned and available for use during periods of challenging weather or in case of an outage in critical electricity infrastructure.

Considering that the challenge of resource adequacy is emerging towards the end of this decade, the design of a capacity mechanism should start immediately.

CONCLUSION 2: FIRM AND FLEXIBLE CAPACITY IS NEEDED TO ENSURE RESOURCE ADEQUACY – A CAPACITY MECHANISM IS NEEDED TO SUPPORT THE BUSINESS CASE

There is a notable absence of "missing money" for all the firm and flexible technologies assessed, indicating that the financial case for new firm and flexible capacity is lacking. Investments in this new capacity are unlikely to materialise based solely on current market conditions, which means that new tools are needed to ensure resource adequacy.

Over the past decade, several EU countries have introduced capacity mechanisms in response to similar challenges concerning resource adequacy. It is evident that such a tool could play a crucial role in attracting new investments in firm and flexible capacity in Finland.

CONCLUSION 3: CAPACITY MECHANISMS COME WITH A COST, BUT DO HAVE BENEFITS TO SOCIETY IN TERMS OF INCREASED RELIABILITY AND LOWER WHOLESALE ELECTRICITY PRICE

There is an additional cost with the introduction of a capacity mechanism. In return, there is (a) increased reliability; (b) less risk of load shedding; and (c) lower and more predictable area prices. All the aforementioned increase the attractiveness of Finland as an environment for new industrial investments.

CONCLUSION 4: THE CAPACITY MECHANISM SHOULD BE DESIGNED CAREFULLY TO ENSURE IT SOLVES THE IDENTIFIED CHALLENGES

As well as bringing benefits, the implementation of a capacity mechanism incurs societal costs. It is important that any capacity mechanism is meticulously designed to address Finland's overarching resource adequacy challenge in the most cost-effective manner possible.

It is important that the capacity mechanism design focuses on procuring the right type of capabilities. For example, capacity should possess the ability to start and stop frequently, bridge energy gaps and provide reserves.

A further practical consideration is the timeline: the resource adequacy challenge is projected to emerge by the end of the 2020s. Therefore, it is crucial to thoroughly investigate measures that could effectively address this challenge within this timeframe. For instance, the targeted, non-fossil flexibility scheme should be a priority for investigation, along with other innovative solutions. The design choices for a capacity mechanism could also impact the implementation time, such as a centralised design compared to a decentralised one.

Although the immediate timeline is a key consideration, it is also important to understand that the Finnish power system will further evolve towards carbon neutrality. Any capacity mechanism design will also need to evolve to support the needs of the system of the future. This need should be reflected in the overall capacity mechanism framework.

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AFRY Management Consulting has carried out the study for Wärtsilä in close collaboration with them.