Assessment of future capacity solutions to ensure resource adequacy in the Finnish electricity market

Public Report, June 2023

Table of contents

AFRY MANAGEMENT CONSULTING

June 2023

Oliver Pearce, Director
oliver.pearce@afry.com

Matias Peltoniemi, Manager
matias.peltoniemi@afry.com

AFRY Management Consulting provides leading-edge consulting and advisory services covering the whole value chain in energy, forest and bio-based industries. Our energy practice is the leading provider of strategic, commercial, regulatory and policy advice to European energy markets. Our energy team of over 250 specialists offers unparalleled expertise in the rapidly changing energy markets across Europe, the Middle East, Asia, Africa and the Americas.

Disclaimer

While AFRY considers that the information and opinions given in this work are sound, all parties must rely upon their own skill and judgement when making use of it. AFRY does not make any representation or warranty, expressed or implied, as to the accuracy or completeness of the information contained in this report and assumes no responsibility for the accuracy or completeness of such information. AFRY will not assume any liability to anyone for any loss or damage arising out of the provision of this report.

The report contains projections that are based on assumptions that are subject to uncertainties and contingencies. Because of the subjective judgements and inherent uncertainties of projections, and because events frequently do not occur as expected, there can be no assurance that the projections contained herein will be realised and actual results may be different from projected results. Hence the projections supplied are not to be regarded as firm predictions of the future, but rather as illustrations of what might happen. Parties are advised to base their actions on an awareness.

Executive summary

In January 2023, Fingrid requested AFRY to initiate a study focused on the potential ways to support and improve power system adequacy in Finland. The scope included: i) Identification of the potential need for change based on Fingrid's Forecast; and ii) Considering a short-list of viable options for supporting adequacy in the Finnish market. The time horizon for the study was until 2030. This report presents a summary of AFRY's work including our views on the potential way forward. We are grateful to Fingrid and stakeholders who have supported the work through active participation in the discussion on the assignment topics.

Finland's electricity production structure will change considerably in the next few years. We expect to see a positive economic environment for investment in new low carbon generation, such as onshore wind, which in turn is driving investment in industrial demand, not only to decarbonise existing processes but also new industries locating to Finland. An increasingly large share of electricity production will become weather-dependent, sourced from wind and solar generation capacity. Fingrid estimates that at the end of the decade, wind power will generate about half of the electricity produced in Finland. Alongside the changing generation mix, electricity consumption is expected to grow strongly due to carbon neutrality objective and new industrial demand, especially in the second half of the 2020s. At the same time, as demand will rapidly increase, a range of low-carbon flexibility resources will be needed to balance the system, including demand side response.

In the context of a rapidly evolving electricity sector, Fingrid Forecast scenarios for future Finnish power system and Fingrid's adequacy analysis highlight potential challenges with electricity adequacy[1], especially during longer periods of cold weather and low wind production. In particular, the scenarios indicate that a prolonged period (i.e. days to weeks) combining either low wind power with cold weather conditions and/or a disruption in the availability of production or imports may bring challenges to adequacy of electricity. This is despite an expected significant increase in demand response.

Finland, as part of the European internal market, has thus far relied on an energy-only market as the main tool to attract and steer investments in electricity generation and consumption: that is, investments have been driven by market prices. System adequacy has been supported by a Strategic Reserve (a form of targeted capacity mechanism) and relatively large amounts of imports. The existing arrangements have had significant success in supporting secure system operation and security of supply as well as supporting decarbonisation and bringing major social welfare benefits through efficient sharing of resources with neighbours. Investments in new capacity have taken place without the need for additional support, notably Olkiluoto 3 and large volumes of onshore wind; investment in flexible storage in the form of grid connected batteries has also taken place (albeit some investments in storage have relied on revenues from the reserve capacity market). In short, well-functioning short-term markets based on marginal pricing have helped to ensure efficiency in dispatch and investment decisions.

However, in the future, relatively infrequent situations such as high electricity demand period with low wind conditions or major disruptions in the power system result in system adequacy challenges over a long period (days to weeks). This requires investment in firm and flexible production, or demand side response or storage that can respond over a longer timeframe of days to weeks. This type of investment is challenging under the current market design. An alternative solution may be needed to support the investment required to ensure system adequacy i.e. the creation of a dedicated capacity solution. Such a solution will have a cost for consumers and the design will need to be carefully considered. Finland is not an uncommon example when looking at Europe and, in the Nordics, Sweden is beginning to see a somewhat similar challenge emerging with Svenska Kraftnät recently releasing a report on the need for a capacity mechanism[2].

Our report presents five short-listed solutions that could be considered to tackle the potential future capacity adequacy issues in Finland. The solutions aim to provide a mix that can alleviate the concerns in short term, as well as further into the future. The short-listed solutions are evaluated based on high-level criteria to highlight the possible benefits and downsides of each solution. Through this report, we aim to raise awareness of the topic and initiate further discussion concerning the potential for and design of a future Finnish solutions to ensure electricity adequacy.

1. Electricity supply adequacy refers to the sufficiency or availability of electricity to meet the demand or needs of consumers. Practically, that there is a reliable and steady supply of electricity that can adequately fulfil the requirements of homes, businesses, industries, and other users, equipment, and systems without interruptions or shortages.
2 Read more: Framtidens kapacitetsmekanism för att säkerställa resurstillräcklighet på elmarknaden

1 Concern for electricity adequacy in Finland is moving towards a more complex need for firm and flexible capacity

FINNISH ELECTRICITY DEMAND AND RENEWABLE ELECTRICITY SUPPLY ARE BOTH EXPECTED TO INCREASE SIGNIFICANTLY BY 2030

Finland has set the ambitious target to become carbon neutral by 2035. Achieving the target requires significant effort to decarbonise the current carbon intensive industries and encourages consumers to move towards electricity-based solutions in both heating and transportation. [3]At the same time, huge cost-competitive resource potential, a strong grid, and supportive public opinion mean Finland has significant potential to further develop onshore wind, offshore wind and solar projects compared to other markets. The energy transition thus also creates opportunities for Finland from new industries based on renewable electricity, with green hydrogen production, data centres and battery businesses leading the way and creating economic benefits for Finnish society.

Figure 1 shows that the energy transition is expected to drive a significant and accelerating increase in Finnish annual electricity consumption by the end of the decade (based on Fingrid's Forecast[4]). Most of the change is driven by the increasing electricity demand from industrial use.

Figure 2 shows that the emerging demand is expected to be covered by mainly new renewable electricity generation. Wind power alone could contribute to over a half of the annual generation in Finland by 2030 (equalling to two thirds of installed capacity).

FIGURE 1: FINNISH ELECTRICITY DEMAND BY 2030[5].
Data source: Fingrid

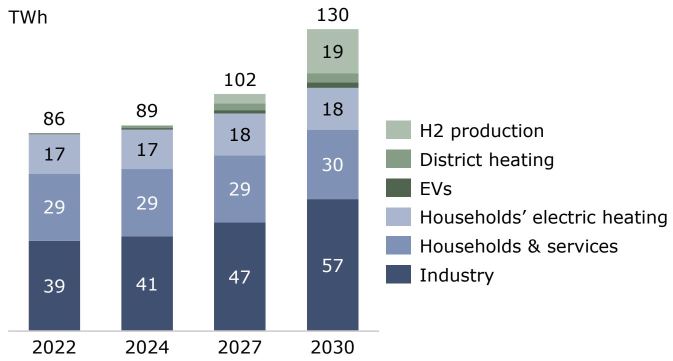
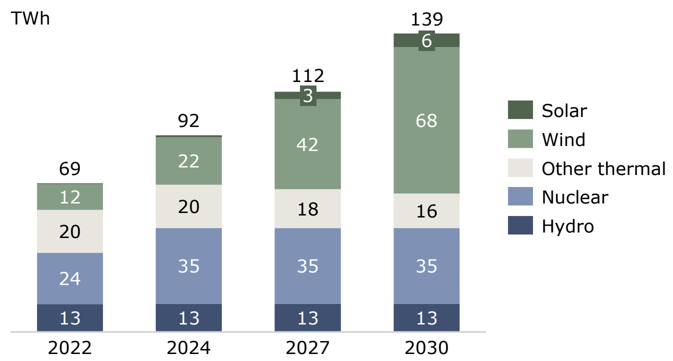


FIGURE 2: FINNISH ELECTRICITY GENERATION BY 2030[6].
Data source: Fingrid



THE ENERGY TRANSITION REQUIRES INCREASING FLEXIBILITY FROM THE POWER SYSTEM – EITHER FROM FIRM, FLEXIBLE PRODUCTION CAPACITY, FLEXIBLE DEMAND OR STORAGES

Since electricity cannot yet be stored long-term in large quantities economically, the supply and demand of electricity must always remain equal in the power system. This requires either more firm and flexible production capacity to support the power system or increased flexibility from electricity consumers. During shorter periods of capacity tightness, new and existing industrial demand will play a key role in supporting the power system, together with the household loads and batteries (demand response growing substantially from the level seen today under the Fingrid's Forecast). It is also noted that there is a growing importance on locationality of the new generation and demand to avoid emergence of bottlenecks into the power system and hence ensure delivery of electricity.

The Loss of Load Expected (LOLE) value indicates the average expected number of hours in a year when resources are insufficient to meet the demand. The threshold for resource adequacy set by the Finnish government is 2.1 hours a year[7]. Tables 1a and 1b illustrate, through this indicator, that under Fingrid's Forecast, challenges with adequacy start to show towards the end of the 2020s. Under the Fingrid's Forecast, the LOLE value rises towards a level just below the government target by 2030, indicating that adequacy becomes more challenging even without disturbances in the electricity supply. (Table 1a). Moreover, the LOLE value increases to levels above the set target in cases of disturbances in the electricity supply or limited demand side flexibility. The challenge is highlighted on weather years with unfavourable weather conditions (Table 1b). See Annex 1 for further details.

3 More background in AFRY report "Hiilineutraalisuustavoitteen vaikutukset sähköjärjestelmään"
4 Fingrid's Forecast is a scenario for the next ten years based on Fingrid's forecast of future developments, used for grid development needs. See Annex 1 for further information.
5 H2 production = Electrolysers of green hydrogen production facilities, District heating = Heat pumps and electric boilers connected to district heating networks, EVs = Electric vehicles. Source: Fingrid's Forecast Q2/2022
6 Other thermal = Coal, natural gas, and peat. Source: Fingrid's Forecast Q2/2022. Estimates were updated Q4/2022 but this study was conducted with the estimate from Q2/2022.
7 Read more: Resource adequacy assessment until 2033

TABLE 1. LOSS OF LOAD EXPECTED IN DIFFERENT POWER SYSTEM CONDITIONS IN FINGRID'S FORECASTS.
Data source: Fingrid[8]

1a. Finnish power system LOLE on average weather conditions (h/a)

Event	2024	2027	2030
Best Estimate	0.2	0	1.9
Olkiluoto 3 outage	4.4	9	29
No imports from Southern Sweden	3.5	4,2	20
Limited flexibility: Households	0.2	0,5	4
Limited flexibility: Industry	0.2	0	2.2
Limited flexibility: Industry & P2X	0.2	0	62
Limited flexibility: Industry & DH	0.2	4	35

≤2h/a

Increasing escalation from 2 h/a

1b. Finnish power system LOLE considering historically three challenging weather years (h/a)

Event	2024	2025	2026	2027	2028	2029	2030
Best Estimate	2	0	0	0	0	6	19
Olkiluoto 3 outage	29	24	17	39	63	144	149
No imports from Southern Sweden	21	21	0	21	30	68	117
Limited flexibility: Households	2	0	0	1	9	21	27
Limited flexibility: Industry	2	0	0	0	0	11	21
Limited flexibility: Industry & P2X	2	0	0	0	5	17	171
Limited flexibility: Industry & DH	2	11	0	21	44	122	168

FIGURE 3. FINNISH POWER BALANCE IN 2030 DURING AN EXAMPLE WEEK OF LOW WIND AND TRANSMISSION LINE OUTAGES BETWEEN FINLAND AND SOUTHERN SWEDEN. *Source: Fingrid*

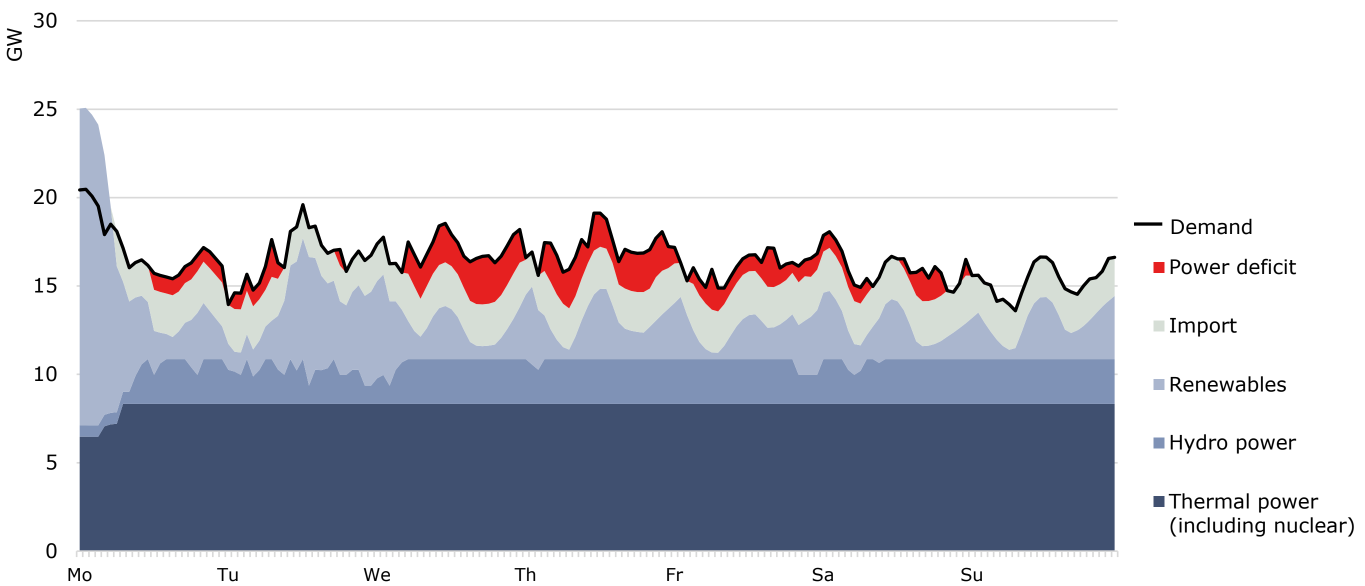


Figure 3 shows a practical example of a challenging weather year: due to low wind and an outage in a cross-border power transmission line on a cold winter week with high electricity demand, firm and flexible capacity is required on multiple consecutive days. Despite the availability of large volumes of demand response, supply cannot always match remaining inflexible demand leading to load shedding. As the example shows that this type of adequacy issues could persist for days or even weeks, there is a need for firm and flexible capacity that can support the system. It is clear from the infrequency of the challenging weather events and uncertainty of the disturbances that there is not a straightforward investment case under the current market conditions to safeguard the Finnish power system and avoid load shedding.

8 (1) Background assumptions explained further in the Annex 2 (2) P2X = conversion of power to into another form of energy (3) DH = District Heating

FIGURE 4. ROLES AND RESPONSIBILITIES IN FINLAND REGARDING SYSTEM ADEQUACY, CAPACITY CONTRACTING AND NATIONAL EMERGENCIES.

MINISTRY OF ECONOMIC AFFAIRS AND EMPLOYMENT

- Responsible of the adequacy of electricity supply in Finland
- Drafts legislation on electricity markets and the national security of energy supply
- Adopts EU regulation into national law
- Responsible of citizen communication during supply shortages

ENERGY AUTHORITY

- Assesses national resource adequacy annually
- Determines capacity requirement for Strategic Reserve and procures required capacity
- Approves the rules for Strategic Reserves
- Oversees lawfulness of any capacity measures

NATIONAL EMERGENCY SUPPLY AGENCY

- Responsible for preparedness planning concerning emergencies and disruptions
- Manages and implements supply of energy during crises

FINGRID

- Operates transmission grid including real-time system balancing
- Managing responsibility of Strategic Reserves, including activation of capacity if needed
- Collects funding for Strategic Reserves
- Communicates the risk of power shortages and the progress of such
- Curtails power demand as last resort during shortages to ensure system adequacy

NEW TOOLS ARE REQUIRED TO ENSURE ADEQUATE ELECTRICITY SUPPLY DURING DISTURBANCES

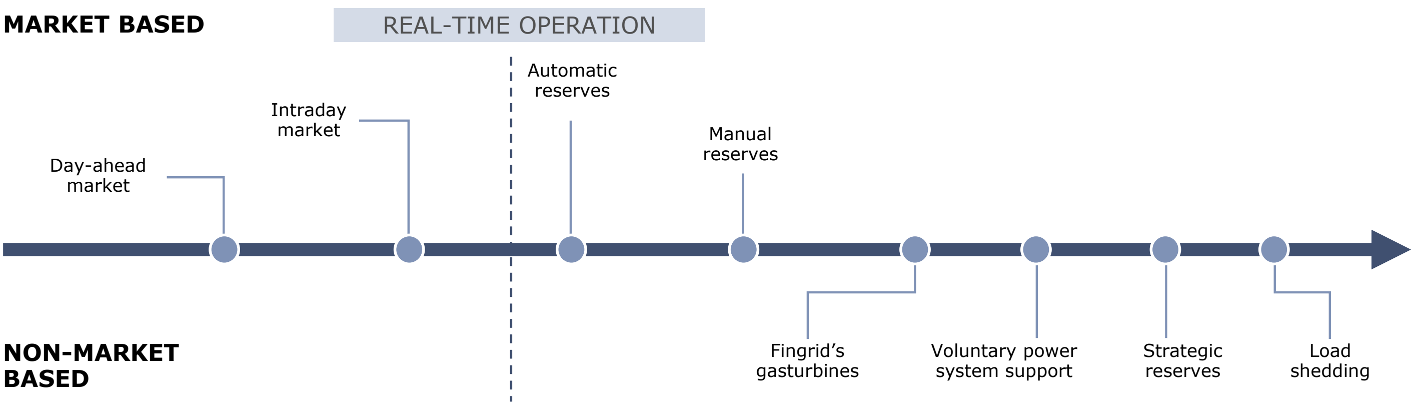
In Finland, the Ministry of Economic Affairs and Employment is responsible for the adequacy of electricity supply in Finland. The Finnish Energy Authority, National Emergency Supply Agency and Fingrid have their own field to cover within the toolbox given from the Ministry, as illustrated in the Figure 4. On the operational level the responsibilities are further distributed to consumers, producers and other parties, e.g. distribution system operators are responsible for performing any physical load shedding.

Finland, as part of European internal market for electricity, has relied on the energy-only market as the main tool to attract and steer investments in electricity generation and consumption: investments have been driven by market prices. In addition to the energy-only market, Finland has so-far secured additional reliable capacity through Strategic Reserves, which are meant to safeguard the Finnish power system against security of supply issues. These existing arrangements have had significant success in supporting decarbonisation and bringing new economic benefits in an efficient manner.

Recent events, notably the energy crisis has pushed the importance of energy security and indicated that prolonged high and volatile energy prices likely result in a push back from consumers and societies. In addition, the current Strategic Reserves mechanism as a backstop to ensure Finnish security of supply has several drawbacks: dimensioned based on averages and thus does not prepare particularly well for unexpected and prolonged events. Additionally, under the current rules, the Finnish Strategic Reserve mechanism has become costly and ineffective to operate.

Figure 5 summarises the current marketplaces for electricity and the tools that can be used by Fingrid to balance the supply and demand of electricity. Involuntary blackouts (i.e. load shedding) are the final measure to ensure that supply meets demand.

FIGURE 5. A SELECTION OF CURRENT TOOLS TO BALANCE THE SUPPLY AND DEMAND OF ELECTRICITY IN ORDER OF UTILISATION



2 Solutions are needed to deliver the required flexibility to ensure electricity adequacy

AFRY has identified five feasible and implementable short-listed solutions for further evaluation in the Finnish context based on the identified need and the existing regulatory framework (Figure 7). In general, high-level designs of the solutions aim to tackle adequacy issues to cover capacity shortage events that could persist from some hours to several weeks. Both demand side and production capacity are equally considered in the short-listed solutions. Not all of the short-listed solutions can be regarded as capacity mechanisms under the EU legislation (namely EU proposal for demand side response product, non-firm access rights, and depending on a final design, direct investment support). Whilst a wide range of other solutions were considered (e.g. two sided contracts for difference, mandatory storage for intermittent producers or de-centralized reliability options), these did not qualify to the short-list due to practical implementation issues e.g. ability to secure reliable capacity, legislative barriers and implementation time issues.

THE SHORT-LIST TAKES INTO ACCOUNT STRICT REGULATION THAT CREATES LIMITATIONS TO AVAILABLE TOOLS FOR SYSTEM ADEQUACY

According to current EU regulation, energy-only markets are the preferred option to ensure adequate electricity supply. The EU regulation states that any resource adequacy concerns should be primarily addressed through energy markets and reserve market reforms. The first steps to address resource adequacy concerns include removing regulatory distortions, removing price caps, increasing internal and cross-border transmission capacity, ensuring market-based procurement of ancillary services and technology neutrality, and removing regulated prices.

A dedicated capacity mechanism can only be considered after market distortions have been removed. Any capacity mechanism must be designed to address a specific identified problem, be dimensioned based on a national reliability standard assessment and comply with the State Aid rules and the EU framework for capacity mechanisms (Figure 6). Implementation of a capacity mechanism requires EU Commission approval. The Commission can block any mechanism if judged incompatible with State Aid rules.

The European Union taxonomy for capacity mechanisms distinguishes between targeted and market-wide solutions. Targeted solutions aim to solve adequacy issues with very specific measures e.g. Strategic Reserve capacity or providing investment support in the form of capacity payments to bring new capacity into operation. On the other hand, market wide solutions aim to secure power system reliability by contracting a mix of existing capacity and new capacity (investments). In all cases, the European Union requirements for any capacity mechanism means that any capacity should be procured competitively and transparently, limiting viable solutions. The taxonomy, together with the European Union regulatory framework, provides guiding principles for short-listing possible solutions for Finland. Additional short-term measures may be applied to all solutions, such as review of grid tariff (locational) structures and incentivization of flexibility into processes e.g. when applying support mechanisms for industrial decarbonization.

FIGURE 6: EU FRAMEWORK FOR CAPACITY REMUNERATION MECHANISMS.
Source: AFRY summary of (EU) 2019/943

DESIGN RESTRICTIONS

Strategic reserve first option

- **a.** Requirement to assess whether CRM in form of Strategic Reserve is capable of addressing adequacy concerns
- **b.** **Only if this is not the case** can another type of capacity mechanism be implemented

CO_2 limit restrictions

- **New** Generation capacity coming online on or after 4 July 2019 is **not eligible** if it emits **more than 550g CO_2** of fossil fuel origin per kWh.
- **Old** From 1 July 2025, generation capacity that was online before 4 July 2019, is **not eligible** if it emits:
  - **more than 550g CO_2** of fossil fuel origin per kWh; and
  - **more than 350kg CO_2** of fossil fuel origin on average per year per installed kWe[1]

DESIGN PRINCIPLES

Capacity mechanisms shall…

- Be temporary
- Not cause undue market distortion and not limit cross-zonal trade
- Not go beyond what is necessary to address specified adequacy concerns
- Select capacity providers via a transparent, non-discriminatory and competitive process
- Provide incentives for capacity providers to be available in times of expected system stress
- Ensure that remuneration is determined through the competitive process
- Set out technical conditions for participation in advance of the selection process
- Be open to all resources capable of providing the required technical performance

FIGURE 7: SHORT-LISTED SOLUTIONS TO PREVENT CAPACITY SHORTAGES

SOLUTION 1

EU PROPOSAL: PRODUCT FOR DEMAND RESPONSE AS PEAK LOAD SHAVING

— An additional market product to foster demand response that is currently not actively participating

— Aim to prevent/alleviate shortage events by reducing peak demand when needed

SOLUTION 2

VOLUNTARY NON-FIRM ACCESS RIGHTS

— Creating a market based / voluntary tool for Fingrid to form a priority queue for power curtailments during system stress events

— Aim to alleviate adequacy issues real-time by reducing demand rapidly

SOLUTION 3

INTERIM CRISIS RESERVES

— Nationally acquiring sufficient level of firm and flexible capacity into a national out-of-market reserve. With a possibility to re-sell some of the units in later point in time when enduring solution is in place.

— Aim to create a quickly deployable interim solution to secure adequate electricity supply to ensure security of supply during specifically defined exceptional events (definition of which still unclear), until a long-term solution can be put into place

SOLUTION 4

TARGETED SOLUTIONS FOR NEW INVESTMENTS

— Establishing a national support scheme as an auction of capacity payments to incentivize investments in new flexible generation or consumption, or to improve flexibility of existing assets and systems

— Aim to increase overall system firmness and flexibility to better balance the demand and supply in the future power system

SOLUTION 5

MARKET WIDE CAPACITY SOLUTIONS

— Capacity solution utilizing both existing and new assets with aim to increase system reliability by securing enough reliable capacity for potential system stress events

— Could be organized with reliability options to both incentivize capacity contract holders to be operational during supply shortages and provide a hedge for consumers against high prices

The solutions short-listed by AFRY provide tools for Finland to ensure and maintain flexibility and system adequacy going forward.

SOLUTION 1

EU PROPOSAL: PRODUCT FOR DEMAND RESPONSE AS PEAK LOAD SHAVING

Market product for peak load shaving could serve a purpose to incentivize and foster demand response that is currently disengaged or not directly exposed to market signals

The European Commission held a public consultation on the future direction of the electricity market design in early 2023, which resulted in a Commission regulatory revision proposal[9]. Both the consultation and the consequent regulatory proposal included a new tool called "ancillary service for peak load shaving". According to the Commission, the tool could foster demand reduction and energy shifting (through demand response, storage and other flexibility solutions) at peak times, a peak shaving product could be defined and considered as an ancillary service that could be bought by system operators. This would incentivize flexibility when fossil fuel capacity is needed the most in the system. It would be important to ensure such a product is cost effective if implemented over the long term.

It should be highlighted that there is high uncertainty in using and implementing such a tool. In current market design and as shown in practice in Finland, there is already demand side response emerging fully market based, triggered by short-term market price signals. Therefore, creating an efficient and economically viable capacity product around demand response may be difficult and risks simply moving demand response between market segments (impacting liquidity), or providing capacity payments to demand side response that would be active even market based.

Fingrid's Forecast for the future power system show that the Finnish electricity system may have adequacy issues, especially during disturbances or longer lasting weather driven events, despite the estimated strong market-based increase in maximum amount of demand response to 7.3 GW by 2030 (compared to around 0,8 GW today). A peak load shaving tool could incentivize demand response that is not currently directly exposed to market signals (e.g. fixed price contracts, no market access e.g. due to small size, "disengaged consumers"), or by aggregating households that are not currently eligible/interested in offering their flexibility. This incentivization would take place through capacity payments for contracted demand side response.

If a peak shaving tool is implemented, it would have to be carefully designed to not remove/shift demand side response between established marketplaces (i.e. day ahead market, intraday market and balancing market). A more efficient way to reach activation of demand side resources through this tool could be organized as follows (as an alternative to the EU proposal):

- Demand side response capacity is contracted via auctions, providing successful bidders capacity payments in return for their reliability to act if/when needed.
- Contract holders have the freedom to activate contracted demand side response in organized markets, based on the price signals. However, should demand response not be activated by the contract holder itself, Fingrid would have the right to activate the demand side response closer to real time.
- If a resource is activated by Fingrid, no separate energy payments would be provided to the contract holder. Capacity payments would still be made, however.
- Thereby, the contract holder would have an incentive to utilize the markets to activate the demand side response during system stress events in order to receive energy payments (cost reductions)
- In any case, measurement of activation would require a baseload methodology that would provide a tool to compare the demand reduction actions to deemed baseload demand and thereby validate the demand side response activation.

EU PROPOSAL: PRODUCT FOR DEMAND SIDE RESPONSE AIMS TO SECURE AND INCENTIVIZE DEMAND SIDE RESPONSE TO ENSURE SHORT-TERM SYSTEM FLEXIBILITY

DESCRIPTION

- Demand Side Response product as defined in the EU electricity market regulation change proposal
- Incentivize and foster demand response that is not currently directly exposed to market
- Would mainly target peak load shaving rather than shifting, considering the problem definition. Available for demand response only

IMPLEMENTATION

- Competitive bidding process, with selection based on the lowest cost of meeting pre-defined technical and environmental criteria
- Contracts concluded D-2 or D-1, for duration no longer than one delivery day
- Activation could be incentivized within spot markets, but allow also real-time activation of unused capacity
- Consideration can be given to whether funding would be through imbalances or through grid service

BENEFITS

- May enable tapping into currently inactive/disengaged demand flexibility e.g. through aggregation
- Part of the EU toolbox and thus implementation may be quicker
- Such additional incentives could theoretically incentivize new consumption to develop more flexibility in their asset design. However, short contracts may be challenging for such decisions.

CONSIDERATIONS

- Added complexity to the existing market design and potentially unclear effectiveness
- Some DR may only be activated for a limited number of consecutive hours – beyond this, it will start to disrupt processes / living standards
- Product cost-effectiveness to be ensured– risk of moving liquidity across marketplaces or contracting DR that would be active even market-based
- Legislative considerations for any variants to the EU proposal

9. Final formulation and implementation timelines are still unclear. Read more: Amending EU regulations to improve the Union's electricity market design

SOLUTION 2

VOLUNTARY NON-FIRM ACCESS RIGHTS

Non-firm access rights could provide a market-based / voluntary tool to form a priority curtailment queue that could be quickly utilized to alleviate adequacy issue events in real-time

In Finland, the current grid connection framework functions as a firm access right i.e. any power curtailment is optional (with exception of operational security reasons) and grid users can trade/withdraw/inject electricity how they choose. Therefore, there is no market-based / voluntary priority curtailment queue that could be quickly utilized to alleviate adequacy issue events in real-time. Even so, two important notes should be made:

1. In Finland, a lot of demand side response is already taking place through market-based actions in different market segments.
2. The current connection contracts could already be deemed to be non-firm access rights (albeit not a very flexible one) as curtailment due to operational security reasons is allowed.

By providing an option to sign for a non-firm access right, consumers could offer real-time flexibility in return for a cost reduction. It should be carefully considered whether non-firm access should target only transmission grid connected assets. Typically, households need to have firm access by default as power curtailments would require greater awareness of the system and consequences of the curtailment. Still, the possibility of voluntary aggregation at lower voltages should be explored, requiring TSO/DSO cooperation.

It is noted that this solution comes with a risk of high costs (or high cost reallocation to firm users) if a high amount of grid users opt for non-firm access based on the expectation that that they never or very rarely be curtailed.

VOLUNTARY NON-FIRM ACCESS RIGHTS WOULD PROVIDE CONSUMERS A POSSIBILITY TO OFFER REAL-TIME FLEXIBILITY IN RETURN FOR A COST REDUCTION

DESCRIPTION

- Power system access rights in Finland are currently firm – grid users can produce to and withdraw theoretically unlimited energy from the power system
- Fingrid balances the system and does counter trading as required
- Non-firm access rights would be an optional choice for transmission grid-connected consumers to express their willingness to be flexible in real-time

IMPLEMENTATION

- Gird users could be incentivised to be flexible by offering voluntary non-firm access
- Non-firm access right holders would receive compensation (e.g. pay less grid charges) for accepting to be priority curtailed/disconnected whenever there are adequacy issues

BENEFITS

- Market-based / voluntary tool to form a priority curtailment queue that could be quickly utilized to alleviate adequacy issue events in real-time
- Could offer additional incentive for new consumption to develop to be flexible in turn for lower charges.
- It could also attract existing consumption to consider their need for firm access

CONSIDERATIONS

- Mainly reactive measure when issues occur.
- Drive towards slightly more centralized system
- Cost-benefit and compensation model needs to be properly designed
- Avoid moving liquidity across markets/solutions
- Availability of demand response to perform curtailment not guaranteed

SOLUTION 3

INTERIM CRISIS RESERVES

Interim crisis reserves as an alternative option, reflecting a need for quickly deployable solution before any long-lasting solution to secure firm and flexible generation

STRATEGIC RESERVE APPEARS TO REACH A DEAD-END

Finland has so far opted for a "Strategic Reserves" capacity mechanism in which contracted peak load capacity ensures the security of electricity supply for the Finnish power system when the planned electricity procurement is not sufficient to cover the anticipated electricity consumption. The size of the Finnish Strategic Reserves has varied between 300 and 600 MW (2023 and 2024 seasons being 0 MW). All contracted capacity is prohibited to participate in the organized markets, which may then lead to higher market prices due to less available supply. Contracted reserve resources must be able to run for 200 hours per contract period. In the context of the foreseen challenge, Strategic Reserve is targeted at ensuring that existing capacity is available rather than incentivising new investment so structurally it does not solve the challenge at hand.

Finnish Strategic Reserves have become harder and costlier for society to operate and activate after European regulatory changes in 2019. Since the reform, Strategic Reserves can be activated only as a last resort measure if all other means in wholesale and balancing power markets have been used. These reserves need to be sold as imbalance energy, priced at Value of Lost Load or Intraday market max price (8000€/MWh or 9999 €/MWh respectively), depending on which one is higher at the time. Therefore, activating these reserves will significantly increase the costs for society and the costs for the rest of the market.

While the current Strategic Reserve product is not operational/economically viable, at the same time, returning to legacy regulation is not viable either due to the EU regulations in force, and due to national legislative restrictions. This implies that Strategic Reserves have reached a dead-end.

CRISIS RESERVE AS A STOP-GAP?

As an alternative option, reflecting the need for a quickly deployable solution for the short term before any enduring solution is in place, the current Strategic Reserves could be replaced with a new interim concept such as interim national crisis reserves to secure firm and flexible generation. Such crisis reserves would then aim to:

— acquire a sufficient amount of quickly deployable firm and flexible generation, with the possibility to sell the units at a later point in time when they are no longer needed; and/or
— acquire to retain the current firm and flexible production assets / demand response assets

This solution would still ring-fence competitive resources from organized markets for the benefit of the security of supply. The procurement of firm and flexible resources under crisis reserves should follow transparent guidelines with the purpose of filling the capacity gap quickly as an interim solution. Since the assets are acquired directly to the national crisis reserve (not functioning under the EU framework but rather on the grounds of sovereignty), the operation of the assets would be out-side-of-market and thus should have more freedom and flexibility (compared to the current Strategic Reserves). Consequently, also the cost relating to the activation of the resources would be part of the total costs of the solution, rather than having a market price.

The crisis reserve would be put into use to cover the shortfall of Finland's own electricity production in an exceptional event, by decision of the Government or a ministry. The final definition of such events should be further defined, and hence possibly affecting the operational feasibility of this solution. Crisis reserves could be started in a situation where all other measures (e.g. wholesale electricity markets and reserve markets) have been used. As a consequence, the crisis reserves would not be active in the organized markets and thus the funding would have to be managed through state support schemes.

CRISIS RESERVES COULD SERVE MORE SPECIFIC AND INTERIM OBJECTIVES FROM SOVEREIGNTY OF SECURITY OF SUPPLY PERSPECTIVE

DESCRIPTION	IMPLEMENTATION	BENEFITS	CONSIDERATIONS
– Reserve capacity to secure adequate electricity supply during possible exceptional situations (to be defined) – Abolishing the strategic reserves and moving to completely out-of-market crisis reserves where required firm and flexible capacity would be owned by a specified crisis entity – Possibility to sell acquired new assets/units in later point in time when not needed anymore	– Crisis reserves could follow e.g. procedures similar to the current adequacy assessment and competitive procurement, but having more emphasis on extreme events – Completely out-of-market solution where suitable crisis entity would directly acquire and own required firm and flexible capacity to prepare from national security perspective e.g.: retention of exiting conventional production units, engines, container-based generators	– Ensures adequate electricity supply for potential long duration disruptions – Adding firm and flexible supply to complement demand side responses in the Finnish power system – Re-sale value of mobile assets can be considered in the overall cost-benefit assessment to soften the cost burden	– Undefined legal backing, roles, definition of exception event and operational procedures – Non-market-based solution, could be considered discriminatory and inefficient – May be costly and hard to justify for pubic if dimensioning weights extreme events more than averages, and if rarely activated/used

SOLUTION 4

TARGETED SOLUTIONS FOR NEW INVESTMENTS

Targeted solutions for new investments would be a technology-neutral solutions with aim to attract new investments in firm and flexible capacity

Fingrid's Forecast of the future Finnish power system shows a lack of firm and flexible capacity, which may be increasingly hard to attract based purely on energy-only market signals (as Chapter 1 outlines). Therefore, targeted competitive solutions are included in the short-list.

The European framework for capacity mechanisms creates a major uncertainty for targeted solutions. EU Guidelines on State aid for climate, environmental protection and energy have a dedicated section for "Aid for the security of electricity supply". Figure 8 shows part of these State Aid guidelines that may challenge the targeted nature of this solution.

An alternative path towards this solution emerged in March 2023 when the European Commission proposed to reform the EU's electricity market design. As part of the change proposals, a Flexibility Support Scheme is proposed. The scheme, as proposed, would be designed to target for new investments in flexibility. Such a Flexibility Support Scheme would consist of payments for the available capacity of non-fossil flexibility. The scheme would be limited to new investments in non-fossil flexibility. This could open a more compatible framework for a targeted investment support.

DIRECT INVESTMENT SUPPORT AS A SIMPLE WAY TO INCENTIVISE NEW FIRM AND FLEXIBLE CAPACITY TO THE FINNISH SYSTEM?

One alternative suggested in the stakeholder discussions was to explore the possibility of using the measures under the current Finnish electricity market act. Until June 2023, the Finnish electricity market act included a possibility to organise a public tender for new generation capacity to secure energy supply[10]. In this case, the government would decide on organisation of a public invitation to tender for new electricity generation capacity or demand side response in order to secure energy supply. Such tender would only be made in the case that the energy supply is not enough to meet the electricity demand in Finland, considering that electricity generation assets planned or under construction, transmission connections and the implemented demand-side measures, and the sufficiency of electricity cannot be secured by other measures. However, the option for national tenders was taken out from the EU electricity market legislation in 2019, and the changes implementing the EU legislations has been adopted in Finland fall 2022, removing the section from the Finnish Energy Market Act, effective 1 June 2023 onwards.

Practically, this kind of investment support would be classified as State Aid, however not paid by consumers (via bills) but as an upfront payment. Therefore, the source of the funds should be discussed as it would come from a central source (i.e. government budget). Investment support could be entirely based on price per MW installed, or per MWh, or a combination. Other pre-defined criteria could be included, such as maturity of the project, firmness, location etc. The final design on payment structure, competition parameters and legal viability should be further investigated.

CAPACITY TICKETS AS A COMPETITIVE TARGETED SOLUTION TO INCENTIVISE NEW INVESTMENTS TIED TO RELIABILITY?

Capacity tickets is a tool that aims to offer required additional incentives for new investments to stay in or enter the market, by topping up the revenue streams from the existing wholesale electricity markets (that may not provide sufficient revenues to justify investments on their own). Capacity tickets with fixed payment (€/MW), long duration (e.g. 5-10 years) and a 2–4-year commissioning timeline from auction aim to provide an such additional financial incentives. An advantage of such measure is that capacity is procured in advance and thus ensures future power system reliability. On the other hand, the issue is how much to procure to avoid over procurement and additional cost to society.

According to the solution framework, successful bidders in capacity ticket auctions are granted a capacity contract, providing a predictable revenue stream for a predetermined duration (e.g. 10 years), with fixed payment based on the available capacity. The capacity payments ensure a stable and predictable flow of income to partially cover fixed (investment) costs. Capacity ticket holders would still be free to participate in spot and reserve markets.

Capacity payments do not affect the operation of the power plant and do not directly distort market-based dispatch. However, new investments supported by capacity tickets may indirectly push existing firm and flexible generation assets / expensive DSR out of the market by having a lower cost to produce electricity, and thereby also creating lower electricity prices. The combined effect may cause a distortion to electricity market pricing, as well as having an effect on system flexibility. Therefore, regulatory oversight is required to avoid compromising market-based dispatch due to possible underbidding from capacity ticket holders.

FIGURE 8. KEY IMPLICATIONS FROM THE STATE AID RULES SOLUTIONS ACCEPTABILITY

CLAUSE	GUIDELINE	IMPLICATION TO THE SOLUTION
4.8.4.3 Eligibility / 343	The aid measure should be open to all beneficiaries or projects technically capable of contributing efficiently to the achievement of the security of supply objective. This includes generation, storage and demand response, as well as the aggregation of small units of these forms of capacity into larger blocks.	May require expanding the solution from targeted to market-wide
4.8.4.3 Eligibility / 346	Where technically feasible, measures for security of electricity supply must be open to direct cross-border participation of capacity providers located in another Member State	May require cross-border participation. However, could be investigated if justified technically infeasible.
4.8.5 Avoidance of undue negative effects on competition and trade and balancing / 365	...ensure that the remuneration does not affect decisions of the capacity provider on whether or not to generate	May point more towards the Reliability Option variant

10. Finnish electricity market act 9.8.2013/588 Clause 63.

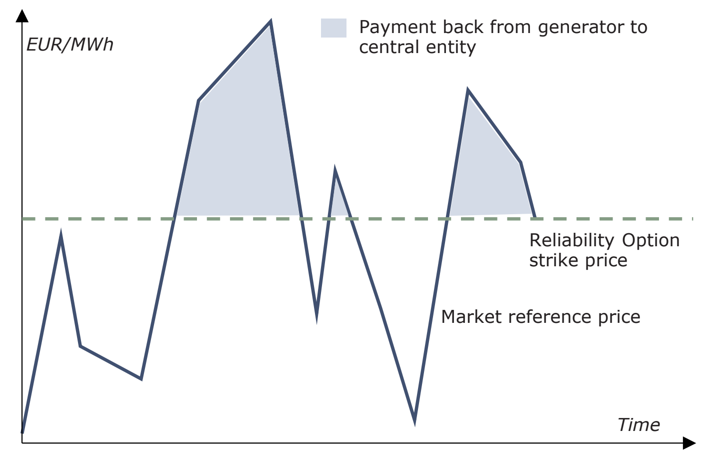
Capacity tickets for new investments should be technology-neutral and aim to attract investments with a short time-to-market in demand response, new or existing consumption assets or new firm and flexible generation (or flexibility additions to existing assets). De-rating factors can be used in auctions to reflect the likelihood of different plant types being able to contribute to capacity requirements during a system stress event. Typically, firm capacity such as gas turbines or reciprocating engines have the highest de-rating factors, while low-derating factors are given to intermittent renewables and short-duration storage which are less reliable in being able to contribute capacity during system stress events.

Capacity tickets for new investments could also take a form of a reliability option where the contract holder would receive capacity tickets but in return would be required to pay back to the contract provider during high price periods (when market price is above agreed/auctioned strike price). This is effectively a one-way Contract for Difference (Figure 9). The successful capacity provider receives capacity payments in exchange for forgoing revenue when the market price is above a defined strike price:

- market price > strike price: capacity provider pays the difference between the market price and strike price back to a centralised entity (aka the Difference Payment); and
- market price < strike price: no payment from capacity provider to centralised entity.

This would incentivize availability of the capacity during high price periods, as well as provide price hedging for end-consumers (given that the pay-back would be routed back to consumers). Such Reliability Option variant would be more suitable for also ensuring availability of generators and demand response through a market mechanism rather than only an availability obligation. However, this variant may have a risk of deterring investment and create barriers for smaller generators due to additional complexity and risks.

FIGURE 9. EXAMPLE OF A RELIABILITY OPTION



TARGETED SOLUTIONS FOR NEW INVESTMENTS WOULD BE A TECHNOLOGY-NEUTRAL SOLUTIONS WITH AIM TO ATTRACT NEW INVESTMENTS IN FIRM AND FLEXIBLE CAPACITY

DESCRIPTION

- Targeted solution to attract new investments in firm and flexible capacity as direct investment support or as an auction of capacity tickets
- Targeted solution should be oriented to capacity in firm MWs that can provide flexibility and firmness to the system in hours of system tightness
- With capacity tickets awarded capacities have obligation to generate when the capacity is called upon to contribute to the security of supply of the system.

IMPLEMENTATION

- Auction for capacity in €/MW/year where awardees receive guaranteed payments for longer term (several years), or one-time payment if direct investment support
- Auction would be for new capacity with date of commission in e.g. 2-4-year horizon to attract fast-to-market technologies
- Technologies downrated by derating factors to reflect their reliability and firmness

BENEFITS

- Potential to attract new investments (either from new assets or revision of existing assets).
- Considering generally low electricity price environment where scarcity pricing and higher price limits are proven to not be societally acceptable, capacity tickets would gap the space which market-based signals traditionally provide
- May be applicable as Flexibility Support Scheme

CONSIDERATIONS

- European Union State Aid rules restricting for targeted solutions
- Time-to-market may be compromised due to long regulatory approval timelines
- Due or undue discrimination for new assets to be able to access capacity and energy market revenues, while existing assets can not access capacity revenues.
- Potential distortions to the existing markets if not well designed and monitored

SOLUTION 5

MARKET WIDE CAPACITY SOLUTIONS

Market wide capacity solutions would target contracting reliable capacity with a mix of existing fleet and new investments

A market wide capacity solution would target on contracting reliable capacity to ensure availability and reliability in the power system. Both existing capacity and new investments would be eligible to participate.

Market wide solutions would have potential to attract new investments (either from new assets or revision of existing assets) to market that either provide demand side flexibility or firm and flexible generation. However, such market wide solution may not attract sufficient new investments as it would be contracting reliability from existing capacity (e.g. in Great Britain the market wide capacity mechanism contracted in 2022 only 10% from new investments)[11].

While there are alternative ways of organising a market wide capacity solution, in this context AFRY recommends a market wide capacity mechanism to take the form of a reliability option, to secure both capacity tickets to attract new investments but also to incentivize availability of the contracted capacity (especially the existing fleet) during stress events.

Many of the technical details would be similar to the capacity tickets for new investments e.g. technologies would be downrated by derating factors, with cross-border participation allowed due to EU regulation (however this could be heavily derated). It should be noted that reliability options would increase market design complexity by requiring another layer of financial settlement and transaction.

MARKET WIDE CAPACITY SOLUTION WOULD CONTRACT RELIABLE CAPACITY FROM EXISTING AND NEW CAPACITY TO ENSURE AVAILABILITY AND RELIABILITY IN THE POWER SYSTEM

DESCRIPTION

- Target on contracting reliable capacity through market wide auction as a mix of existing capacity and new investments
- Capacity product recommended to be reliability option including:
  - Capacity tickets to provide guaranteed income for firm and flexible capacity
  - Financial option to incentivize availability during system stress events

IMPLEMENTATION

- Auction for capacity in €/MW/year where awardees receive guaranteed payments for longer term (several years)
- Auction would be for new capacity with date of commission in e.g. 2-4-year horizon to attract fast-to-market technologies
- Technologies downrated by derating factors to reflect their reliability and firmness

BENEFITS

- Potential to attract new investments (either from new assets or revision of existing assets)
- Ensure availability and reliability form existing capacity
- Compliant with State Aid rules (already implemented in other EU countries), subject to adequacy assessment justifying the implementation

CONSIDERATIONS

- Time-to-market may be compromised due to long regulatory approval timelines
- Cross-border participation may have to be allowed due to EU regulation, however could be heavily derated
- Potential of not attracting sufficiently new firm and flexible capacity investments
- Potentially high total cost and risk of providing excess capacity payments to existing capacity

11. Read more: GB Final T-4 Auction Report 2022

3 A qualitative evaluation of the short-listed solutions shows that solutions that have possibility to bring new firm and flexible capacity to the Finnish system, seem to answer the adequacy concerns best

AFRY has made a qualitative assessment of the short-listed solutions against agreed objectives, as illustrated in the Figure 11.

Figure 10 provides the criteria used for the evaluation, and the motivation for the selection of the respective criteria. This framework provides a simple way for evaluation of the short-listed solutions.

The five short-listed solutions reflect differing ways of preparing for or solving the defined electricity adequacy issue in the future. Our qualitative assessment indicates several high-level findings.

FIGURE 10. OVERVIEW OF THE HIGH-LEVEL EVALUATION CRITERIA

1 **Ability to solve the expected adequacy concerns**

Overall conclusion on whether the solution solves adequacy concerns that are particularly in the scope of this work, meaning from days to week long issues.

2 **Fit towards EU requirements and Finnish national legislative framework**

Evaluate if the Solution is acceptable from the national regulation point of view and/or would require additional justification/CBA for State Aid scrutiny. Applicability for the new EU proposals.

3 **Effectiveness: time to market**

Speed at which solution can become operational and provide meaningful aid to the identified problems. Two dimensions: Time for design and time for actual implementation. This aims to reveal if some of the solutions are more fit as interim solutions or could serve as enduring solution.

4 **Effectiveness: ability to attract required investments or maintain/upgrade existing assets**

Evaluates if the solution is capable to bring required flexibility to the system from new required investments.

5 **Avoid negative effect to the existing organized wholesale markets and liquidity**

Minimizing price distortions in spot and reserve markets.

Avoid moving same capacity between marketplaces.

Avoid contracting capacity that would have been active market based.

6 **Locational considerations**

Evaluate whether the solution can steer location of new investments to respect and aid any grid constraints/needs

7 **Support for climate neutrality**

Evaluate whether the solution can support Finnish climate neutrality targets or whether it is reliant on e.g. fossil fuel based generation.

8 **High-level cost implications**

Evaluate the high-level procurement costs relating to the solution.

FIGURE 11. EVALUATION SUMMARY OF THE SHORT-LISTED SOLUTIONS

Evaluation Criteria	1. EU proposal: peak load shaving	2. Non-firm access rights	3. Crisis reserves	4. Targeted solution for new investments	5. Market wide capacity solution
Ability to solve the expected adequacy concerns	◔	◔	◔	◕	◑
Fit towards EU requirements and Finnish national legislative framework	◕	◑	◑	◑	◕
Effectiveness: time to market	◕	◑	◕	◑	◔
Effectiveness: ability to attract required investments or maintain/upgrade existing assets	◑	◔	◔	●	◑
Avoid negative effect to the existing organized wholesale markets and liquidity	◑	◑	◑	◕	◕
Locational considerations	◕	◕	◕	●	●
Support for climate neutrality	●	●	◔	◕	◕
High-level cost implications	◑	◑	◑	◑	◔

The evaluation indicates that capacity ticket / reliability option based solution may be more fit-for-purpose in Finland, whereas crisis reserves could serve as a sub-optimal interim solution

— EU proposal for peak load shaving product shows decent fit against the evaluation criteria – however it does not solve the adequacy issue of long duration response e.g. days to weeks.

— Non-firm access rights fall short against most of the evaluation criteria, so the solution is less recommendable.

— Interim Crisis Reserve fundamentally shows a reasonable fit-for-purpose but has evident challenges with cost/benefit, being non-market based and possible challenges with climate neutrality. However, it should be generally noted that this is a very challenging concept to assess more in detail in this context as possible events leading to activation of such reserves are not addressed in the adequacy assessment process. Due to the uncertainties in the final design of the solution, the solution requires further feasibility assessment.

— Capacity tickets for new investments are most in-line with the evaluation criteria, with the main challenge being time-to-market and unclear treatment of non-domestic capacity. There will also be an additional cost that should be carefully managed.

— Market wide capacity solutions also show relatively good fit for purpose but raises concerns regarding the total costs as well as the time to market.

There is limited room for solutions that would fit EU requirements and Finnish national legislative framework

— EU proposal for a demand side response product is in the scope of the European Commission market design renewal. However, the details of the EU level are still unclear and unfinished.

— Changing access right firmness most likely is not considered under State Aid rules as it is not directly a capacity mechanism.

— A legal review should be carried out to assess if a national crisis reserve could be implemented as an independent national solution to cover for national security of supply.

— Capacity Tickets and Reliability Options are not new in the European framework. However, implementation would require a process with the European Commission to comply with the State Aid rules and other relevant regulation. In the current regulatory framework targeted solutions may be more difficult to receive acceptance than market-wide solutions.

— Finnish law, that allowed new targeted support schemes, was not complying with the existing EU legislation. The amendment removing the section in the Finnish legislation was adopted in 2022, effective 1 June 2023 onwards. However, the new Commission proposal for Flexibility Support Schemes could open a door for targeted solution: without that it should be noted that EU rules do not allow discrimination between new and existing capacity thus challenging targeted mechanisms (that are not Strategic Reserve).

According to Fingrid's analysis a clear need or new flexible capacity emerges increasingly towards the end of 2020's. Time to market for the different solutions seems to be a challenge compared to the expected emergence of the adequacy concerns

— EU proposal for a demand response product would likely have a relatively short time to market (within few years) due to low regulatory barriers in the EU and a rather simple market design. However, it should be noted that as the product aims to incentivize more demand side response, it will potentially require some investments and implementation time from the assets offering the demand response.

— Crisis reserves could be set up relatively quickly (within few years) by mainly utilizing existing and legacy Strategic Reserves framework, operational procedures, and institutional setup. Legislative work and acquiring required resources would take time.
— Any capacity ticket / reliability option solution would have a challenging time to market because the regulatory process, final design, auction and implementation can take between 5-9 years, noting also the required time for the new investments to materialize.

The future Finnish power system would require more firm and flexible capacity: only few solutions seem to meet the need

— EU proposal for demand side product has short contracts that are unlikely to attract new investments.
— Non-firm access rights are not expected to attract vast new investments; however, these may provide a small incentive for new assets to be flexible by default if assets are compensated for it.
— Crisis reserves would not be designed to attract new investments (except fast deployable units) and thus effectiveness is limited.
— Targeted solutions are fundamentally aimed at attracting new investments by providing a guaranteed revenue stream to complement revenues from organized marketplaces.
— Market wide auction for capacity would target increasing reliability of the system by using mix of existing and new capacity. Therefore, while this measure may attract new investments it will also lean more on existing capacity.

The impact of new schemes on existing organised wholesale markets and liquidity should be carefully considered - capacity mechanisms have an inherent risk of negative impact – reliability options aim to mitigate the risk

— It is unclear whether the EU proposal for a demand side product can be implemented in a way that it would not shift/remove liquidity from e.g. day-ahead markets or compensate demand side response that would be active purely market based.
— Non-firm access rights have the possibility to alter the balance between market-based and centrally determined dispatch when Fingrid has higher control of the real time dispatch rather than following fully market-based dispatch.
— Crisis reserve assets would be fully ring-fenced from the organized market and thus have possibility to negatively affect the spot markets during high price periods if liquidity is withdrawn from the markets.
— Capacity Ticket holders are allowed to take the commercial decision where to offer their energy, subject to being available when called upon as per the capacity contract. Hence, the impact on liquidity should be positive, as long as possible price manipulation is contained with proper regulation and market surveillance. Capacity tickets might distort the market pricing since some producers receive extra revenues via the scheme, but effect may be mitigated with use of reliability option variant.
— Market wide capacity solutions generally may distort the market pricing since some producers receive extra revenues via the scheme. The impact on liquidity should be positive, if possible price manipulation is contained. When all / more producers are receiving extra revenues, it levels the playing field. By using reliability options for market wide solution, contract holders would be incentivised to be available during system stress events.

Well-designed capacity mechanism may include locational steering and support meeting climate targets

— All short-listed solutions rank well in locational consideration as it is possible to take location into account in the solution design e.g. in the auction requirements or in derating factors.
— Majority of solutions rank well in terms of supporting the goal of carbon neutrality as the respective auctions can have e.g. CO_2 limits for the competing technologies. Crisis reserves potentially would have to rely more on the fossil fuelled capacity and hence are rated lower, however the realised impact may be small due to limited activations.

Cost of the solutions varies highly between the short-listed solutions, where a market wide solution is expected to be most expensive. Total costs for each solution will eventually depend on the design and contracted capacity amount

— Annual ballpark estimate for the EU proposal for demand response product is around 10 MEUR per year. The estimate is highly dependent on the contracted volumes and hours. For a Finnish consumer, this would mean 0,1 €/MWh (or 0,01 c/kWh) additional payment.
— Non-firm access right cost estimate depends on the actual design. The ballpark estimate is around 10 MEUR per year, depending on the cost reduction level and contracted volumes.
— Generally, it is noted that Crisis Reserves would have a meaningful improvement to the current Strategic Reserves only if the activation price is allowed to differ from the current Strategic Reserve scheme (as explained earlier in this report). With this assumption, the crisis reserve ballpark estimate is 15-30 MEUR per year. This is based on current cost of Strategic Reserves (10 MEUR per year) and estimation of costs for nationally acquired capacity. For a Finnish consumer, this would mean 0,15-0,3 €/MWh additional payment.
— Capacity tickets for new investments ballpark cost estimate is around 50 MEUR per year and is based on the average cost of new investments and only the additional capacity required. For a Finnish consumer, this would mean 0,5 €/MWh additional payment.
— Market wide auction of capacity as reliability options ballpark cost estimate is 500-1000M EUR considering whole production capacity in Finland (15GW). The cost could be lower depending on the set reliability target. For a Finnish consumer, this would mean 5-10 €/MWh (or 0,5-1 c/kWh) additional payment.

12. Estimations based on 1000MW capacity dimensioning. Market wide solution dimensioned based on full Finnish market size 15GW. Consumer costs are based on year 2027 consumption, 102 TWh. These high-level cost estimates consider only the capacity acquisition, and do not consider costs relating to any energy activations.

4 Conclusions and next steps highlight that there are viable solutions, but swift action forward is recommended

This report outlined, based on Fingrid's Forecast, a high-level view of the expected future Finnish electricity market and power system, focusing on system adequacy. It also highlights some potentially emerging issues that the current market design faces in terms of attracting new market-based investments going forward. To address these concerns, a set of five short-listed solutions are presented, complemented by an evaluation against a selected set of criteria to illustrate their strengths, weaknesses and ability to alleviate expected adequacy concerns. It should be highlighted that even if a capacity solution would be implemented in Finland, retention of the current market design with reflective price signals, effective de-centralized dispatch and transparency shall be considered as a precondition.

CONCLUSION 1: FINGRID'S FORECAST SHOW CAPACITY ADEQUACY CONCERNS IN THE FUTURE FINNISH POWER SYSTEM IN TIGHT WEATHER CONDITIONS AND/ OR MAJOR OUTAGES IF NO NEW FIRM AND FLEXIBLE CAPACITY IS RELIABLY SECURED

Fingrid's Forecast shows that in case of difficult weather events and/or major power system disturbances, there is a need for some additional flexibility or production capacity to meet the demand. Such events in this case mean either a long-lasting disturbance at a large production plant or interconnector, or several days or more of cold winter period combined with low wind. It should be highlighted that significant amount of demand side flexibility is required even without any disturbances in the power system. For this reason, a discussion should be opened for the possibility of having some type(s) of capacity solutions in place to support system security and adequacy in the late 2020s.

Any solution taken forward, must be scalable to meet the future adequacy needs as the amount of required capacity may vary due to large uncertainty of the scale of demand growth, estimated market-based investments in flexibility and other assumptions (i.e. availability of thermal generation in future).

CONCLUSION 2: SOLUTIONS THAT HAVE POSSIBILITY TO BRING NEW FIRM AND FLEXIBLE CAPACITY TO THE FINNISH SYSTEM SEEM TO ANSWER THE PROBLEM BEST

Fingrid's analysis show that the future Finnish power system may face issues during cold and low wind periods or during power system disturbances, requiring firm and flexible production capacity to support the system over days and potentially weeks. The requirement for long duration response shifts the focus towards solutions that support investments in production or long duration storage.

Targeted investment support solutions and reliability options (targeted or market wide) also seem to fit the purpose well. However, in these cases the implementation time and total cost are potentially limiting factors.

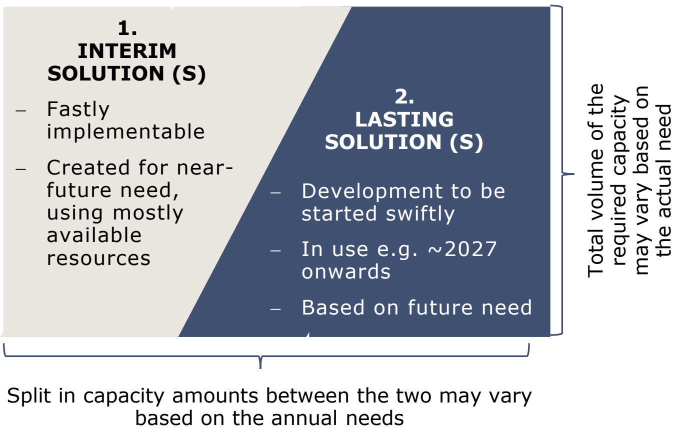
Crisis Reserve seems to fit the purpose moderately, as it has an advantage of a fast implementation time and the ability to contract whatever is needed to ensure security of supply in extreme and exceptional events. However, the final definition of such exceptional event or a crisis may limit the feasibility of this solution, especially under non-crisis circumstances. Furthermore, the cost/benefit balance of such reserves is a challenge, together with required sound legal review/setup and potential difficulties regarding negative market impact and transparent acquirement of the capacity.

The EU proposal for demand response as a market product and non-firm access rights are primarily aimed at demand flexibility, which is a valuable tool in hourly and daily balancing, but not adequate in extreme events. Generally, we conclude that emergence and activation of demand response is for market to solve based on market price signals.

CONCLUSION 3: WHILE THERE ARE VIABLE SOLUTIONS TO ANSWER THE PROBLEM, MOST HAVE CHALLENGES TO BE IMPLEMENTED IN THE SHORT TERM – A SUB-OPTIMAL INTERIM SOLUTIONS MAY BE NEEDED

The short-list shows that there are viable solutions which could be implemented. The implementation time, fit for purpose and total costs vary between different solutions. Due to long implementation times of any capacity mechanism, there may be a need for complementary solutions if the expected emergence of issues and expected implementation timeline of most fit solution do not align. However, overlapping solutions may be too costly to be justified. It is also noted that while lasting solutions should be compatible with full decarbonization objectives, for interim solutions Fingrid considered full carbon neutrality not as a strict requirement in the short term, e.g. low carbon peaking plants may need to be considered (although low running hours imply low total emissions).

FIGURE 12. FINAL SOLUTION(S) REQUIRE FLEXIBILITY TO REFLECT UNCERTAINTIES



CONCLUSION 4: GIVEN THE POTENTIAL EMERGENCE OF THE ISSUES IN THE FINNISH POWER SYSTEM TOWARD LATE 2020'S, THE DISCUSSION AND DESIGN OF COST-EFFECTIVE SOLUTION SHOULD START SWIFTLY

Regardless of the specific solution, it should be stressed that a proper detailed design of a capacity solution and respective implementation will take a considerable amount of time, usually several years. Therefore, the discussion and potentially final development and implementation of the solution(s) in Finland needs to start swiftly.

Lastly, we emphasize and conclude that the energy transition in Finland has already brought (and is planned to increasingly bring more) net benefits to the Finnish society. Therefore, any capacity solution should be very carefully designed and chosen to ensure that it does negatively affect this transition and reduce net benefits for society.

AFRY provides engineering, design, digital and advisory services to accelerate the transition towards a sustainable society.

We are 19,000 devoted experts in industry, energy and infrastructure sectors, creating impact for generations to come. AFRY has Nordic roots with a global reach, net sales of 24 BSEK and is listed on Nasdaq Stockholm.

Making Future

AFRY
ÅF PÖYRY

AFRY Management Consulting
oliver.pearce@afry.com
matias.peltoniemi@afry.com
afry.com