

SOCIETY OPTIMAL LONG-TERM INVESTMENT FRAMEWORK

Electrification investments and market designs in
Finland and Sweden towards 2040

Commissioned by Fortum
2024

Preface

Finland and Sweden have ambitious targets to decarbonise their economies by 2035 and 2045, respectively.¹ For this to happen, a transformation of the energy systems is a necessity.

The Finnish and Swedish economies will rely more on CO₂-neutral energy², direct electrification of industry, transport, and heating, and indirect electrification of heavy transport and heavy industry using e-fuels. The rapid uptake of electrification comes after a period of only smaller increases in electricity demand during the past 30 years.

There are large investments potentials to supply CO₂-neutral energy, to extend grid infrastructures, to electrify existing industries, and in new energy-intensive industries, such as Power-to-X. The energy system moves from an *operational cost system* to a system governed by large *upfront capital investments*, as the marginal cost of CO₂-neutral energy production is low, but upfront investments are large.

New electrification investments also offer socio-economic potential through an increased number of high-productive jobs in Finland and Sweden, as well as boosting the industrial competitiveness of the two countries. To unlock further electrification investments, a long-term investment framework is needed.

Against this backdrop, Fortum commissioned Copenhagen Economics to conduct a study on the societal economic potentials of electrification investments in Finland and Sweden towards 2040 and to assess and

recommend optimal market designs for enabling the energy transition in Finland and Sweden.

In this report, we first estimate the additional investment potentials and economic benefits for Finland and Sweden from reaching the respective decarbonisation targets, as well as reaching the countries' ambitions to double their electricity productions. The electrification investments create benefits from supporting jobs, value added, and taxes in the Finnish and Swedish economies.

The future electrification investments presented in this report are forecasts based on output from our economic model, INTERSECT, and cannot be directly compared to announced investments by individual companies. Our model simulates the economy's expected decarbonisation path in response to politically defined electrification targets, given available technologies. This offers insights into future sector composition, jobs etc. in a future decarbonised economy for Finland and Sweden.

Then, we discuss what long-term investment framework and market instruments are needed for these benefits to materialise.

Finally, we recommend a package of market instruments that Sweden and Finland can implement to best enable the economic benefits. The package of market instruments addresses main challenges along the value chain to optimise the long-term investment framework in a cost-effective way.

A detailed implementation plan and design of the various

instruments in a specific Finnish and Swedish context is beyond the scope of this report. Neither do we analyse power market balancing activities/responses to imbalances in specific hours, nor their exact timing. Rather, we focus on the instruments' ability to ensure stability in general and to support a stable long-term investment framework.

Glossary	Description
Electrification investments	Investments in production processes that <i>consume electricity (demand-side electrification)</i> or <i>produce CO₂-neutral electricity (supply-side electrification)</i> . These cover • Direct electrification: Investments in facilities or products that consume electricity, e.g., electric vehicles, electrified industrial processes, electric heating, etc. • Indirect electrification: Investments in Power-to-X production to produce electrofuels (e.g., CO₂-free hydrogen) that can be used in transport or industry as a substitute to fossil fuels.
Electrified industries/ companies	Industries or companies that rely only on electricity for their production processes, i.e., without using fossil fuels.
Existing industries	Industries that are currently active in Finland and Sweden.
New industries	Industries that arise from new electrification investments, for example hydrogen production.

1) Finnish Ministry of the environment (2022), *Finnish Climate act*; Swedish Ministry of Climate and Enterprise (2021), *Sweden's climate policy framework*. The Swedish target does not include existing LULUCF / development.
2) CO₂-neutral energy includes e.g., electricity from wind, solar, hydro power, and nuclear power.

Executive summary (1/3)

Finland and Sweden have set ambitious targets for reaching net zero emissions

Finland and Sweden have politically set targets to reach net-zero carbon emissions by 2035 and 2045, respectively. Both Finland and Sweden still expect to have positive emissions in 2040 that are offset to different extents by negative emissions,¹ see figures.

Therefore, Finnish industries and households must lower their emissions by at least 80 per cent¹ by 2040 relative to 1990 and Swedish industries and households must lower

their emissions by 75 per cent in the same period. To achieve this, the energy systems will have to become increasingly electrified, relying on CO₂-neutral electricity generation.

The politically stated goal for Finland's electricity generation is to be nearly emission free by 2040, and Sweden aims at producing all electricity from CO₂-free sources by 2040. In 2022, 87 per cent of Finland's and 96 per cent of Sweden's electricity generation came from CO₂-neutral production from either wind, solar, hydro power, biomass, or nuclear power.

The power markets must achieve the decarbonisation whilst also handling *increased demand from electrification*.

The combination of a decarbonisation of the electricity system and the increased electricity demand means that the Finnish and Swedish economies have large investment potentials in power supply, infrastructure, and demand side electrification in coming decades.

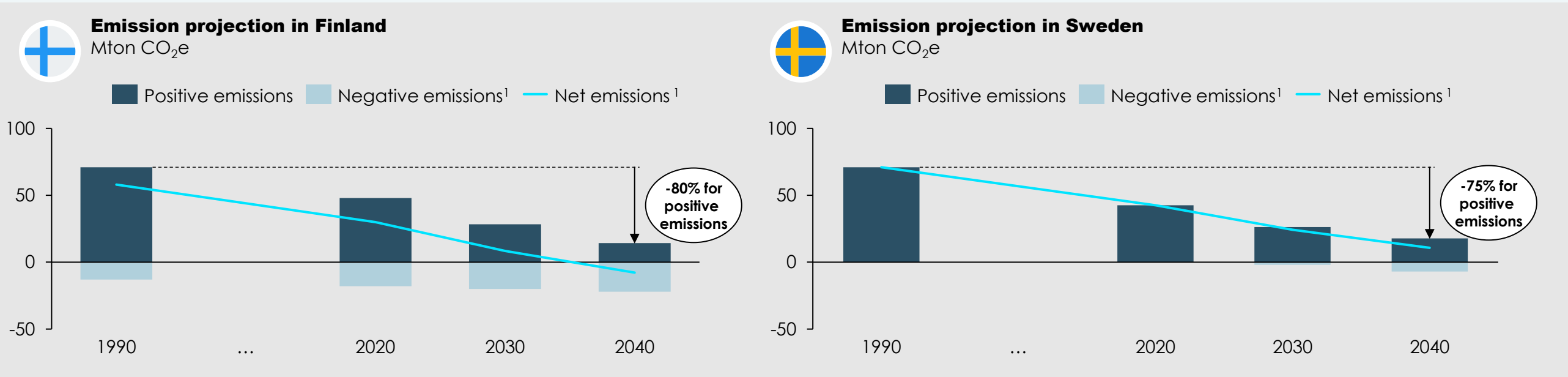


Figure sources: WEF (2023), *Finland is on track to meet some of the world's most ambitious carbon neutrality targets. This is how it has done it* and UNFCCC (2020), *Sweden's long-term strategy for reducing greenhouse gas emissions*.

¹) In an update of the Finnish negative emission sink, the negative emissions were smaller than in previous estimations, see Helsinki Times (2023). In this work, we use the previous estimation. The Swedish target does not include existing LULUCF development. The target for other negative emissions is around 10 Mton CO₂e in 2045 from converting agricultural land to forest, BECCS, and payment for negative contributions in other countries.

Executive summary (2/3)

Decarbonisation pathways

Electrification in Finland and Sweden can take different pathways. We analyse **three scenarios** for the future electrification of the Finnish and Swedish economies:

1. Delayed electrification (baseline). In this scenario, Finland and Sweden will follow a static policy framework with no new political push to decarbonise or electrify the economies, with low likelihood of reaching their climate targets. Electrification investments happen primarily through already cost-effective solutions, for example solar power and electric vehicles.

2. Ambitious decarbonisation. In this scenario, Finland and Sweden reach their respective decarbonisation targets. There is a political push to decarbonise the economies, resulting in additional electrification investments and economic benefits that are not achieved in the delayed electrification.

3. Electricity doubling. In this scenario, Finland and Sweden not only reach their decarbonisation targets but also *double* their electricity production, amounting to approximately 160 TWh in Finland and 300 TWh in Sweden by 2040. This would bring additional benefits to Finland and Sweden from increased exports of

electricity, either directly, or indirectly from export products using electricity in the production processes.

Ambitious decarbonisation generates additional EUR 56 billion investments in Finland and EUR 42 billion in Sweden towards 2040

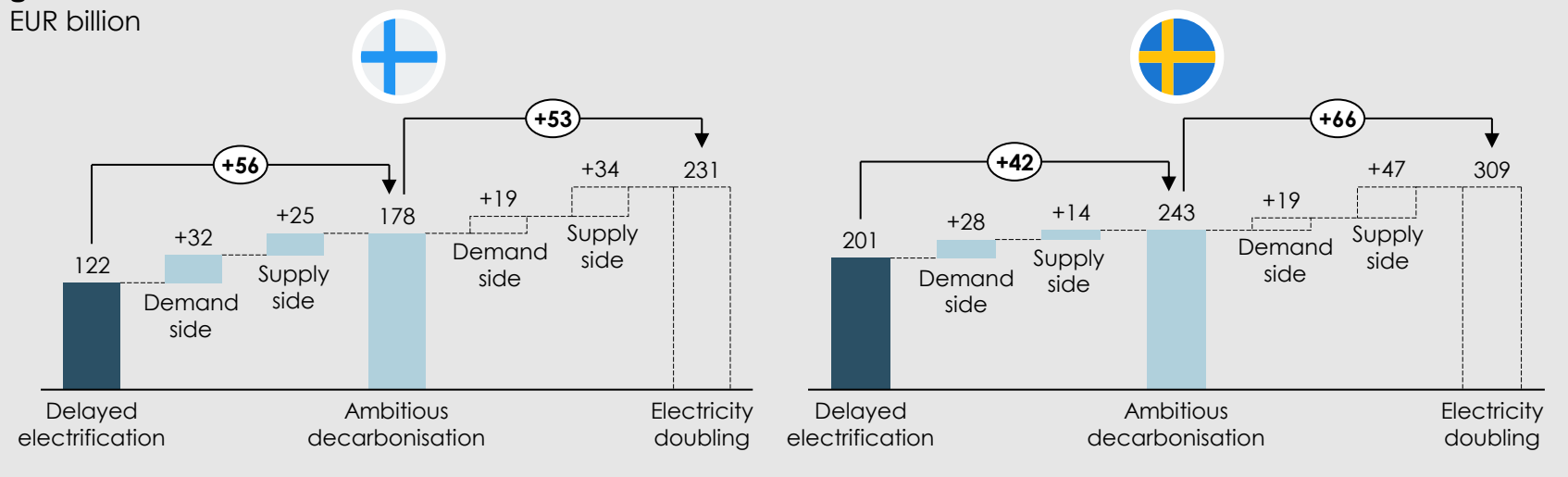
With *ambitious decarbonisation*, compared to a delayed electrification scenario, direct and indirect electrification would generate additional **EUR 32 billion** in demand-side investments in Finland towards 2040, see figure. Realising these investments generates additional supply-side investments worth **EUR 25 billion** in Finland, totalling **EUR 178 billion** in investments towards 2040, see figure. Going to an ambitious decarbonisation scenario, electrified industries could support 61,000 additional jobs in Finland by 2040, which is 19,000 more than in a delayed electrification scenario.

In the *electricity doubling* scenario, additional **EUR 53 billion** investments are generated in Finland towards 2040, see figure.

For Sweden, additional **EUR 28 billion** demand-side and **EUR 14 billion** supply-side investments are generated in the *ambitious decarbonisation* scenario, totalling **EUR 243 billion** towards 2040, see figure. In this scenario, electrified industries support 68,000 additional jobs by 2040.

In an *electricity doubling* scenario, additional **EUR 66 billion** investments are generated in Sweden towards 2040.

Accumulated investments 2025-2040 in the delayed electrification scenario and additional investment generated to reach an ambitious decarbonisation scenario



Note: The numbers do not add up to the totals due to rounding.

Executive summary (3/3)

Reaping all benefits from electrification investments requires new market instruments

The electricity markets in Finland and Sweden operate under an energy-only market design, where consumers pay for energy received and producers are paid for the generated electricity only. In the past years, new generation investments have gone into intermittent capacity, such as wind and solar power. With more intermittent energy from solar and wind, electricity prices will become more volatile, and the risk of inadequate electricity supply increases. Investments in, say, wind power, also reduce profitability as captured prices drop due to market cannibalisation.

Based on responses from interviews with market stakeholders¹ and from reports by the Finnish and Swedish TSOs, we conclude that the current energy-only market design is insufficient in providing a long-term investment framework for electrification investments. If this is not addressed, Finland and Sweden risk missing out on societal benefits from demand-side electrification.

Market instruments to mitigate risks

From a gross list of 11 political and market instruments, we identify **six instruments** that are well-suited to improve the power market design and enable electrification investments in Finland and Sweden. We assess each instrument's likely cost impact in the electricity value chain and on government finances. In addition, we assess their likelihood of enabling the societal benefits, see figure.

Some of the instruments aim to mitigate the same challenge, and therefore it is not necessary to implement all instruments simultaneously.²

The size of societal benefits and costs depends on the local context for the instrument. For example, a capacity remuneration mechanism can have high benefits in areas with limited flexible generation capacity but will be less valuable in areas that have more flexible capacity, or strong interconnection possibilities.

Recommendations for an optimal market design

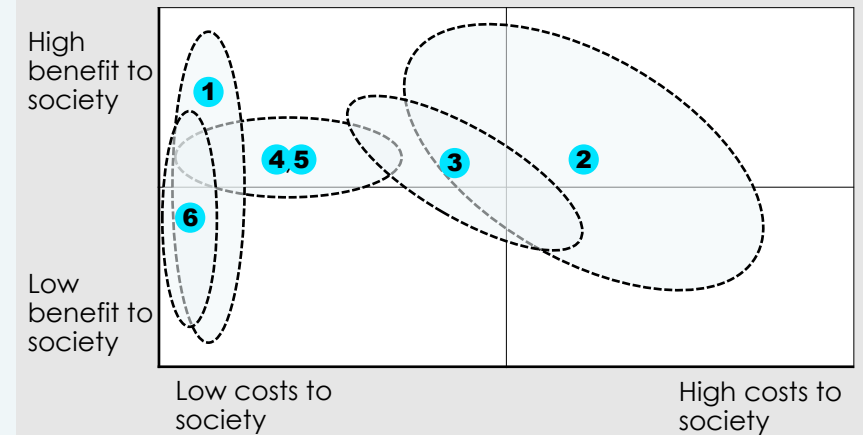
Our recommendations across Finland and Sweden are similar but differ particularly for political stability and the need for capacity remuneration mechanisms.

We find that **Finland** would benefit from implementing a market-wide CRM (2), publicly-backed PPAs (4) or CfDs (5), and geographically differentiated tariffs⁴ (6).

Sweden would benefit from a more stable political environment (1) and from implementing a CRM instrument (e.g. 2 or 3), and publicly-backed PPAs (4) or CfDs (5). The CRM instrument needed in Sweden would be relatively smaller than in Finland due to Sweden's possibilities for interconnectors to other European countries, and because of Sweden's higher share of hydro power in the generation mix.

We cannot say that the instruments ensure new electrification investments. The instruments should be interpreted as collectively increasing the *likelihood* of attracting these investments to Finland and Sweden.

Expected costs and benefits from different policy and market instruments



- 1 A stable political environment** is a prerequisite for a strong long-term investment
- 2 Market-wide capacity remuneration mechanism (CRM)** ensures enough electricity capacity when needed (demand and/or supply)
- 3 Non-fossil flexibility support scheme (NFFSS, a type of CRM)** ensures new, CO₂-neutral demand or supply flexibility.
- 4 Publicly-backed power purchasing agreements (PPA)** alleviate counterparty risks in long-term contracts
- 5 Two-way contracts-for-difference (CfD) auctions** ensure a fixed price for supply-side investors in new capacity³
- 6 Geographical differentiated tariffs** incentivise optimal location of new demand in the grid at low cost⁴

1) We have conducted interviews with large consumers of electricity in Finland and Sweden, see appendix C for our approach. / 2) This is for example the CRM instruments (2 and 3) as well as the publicly-backed PPAs (4) and two-way CfDs (5). / 3) The Swedish government has recently proposed two-way CfD as a potential instrument for risk sharing with nuclear power developers, see Finansdepartementet (2023). / 4) This is not an instrument to implement price zones. Rather, the instrument can in some instances work as a substitute to price zones.

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We estimate electrification investment potentials from decarbonisation of the Finnish and Swedish economies

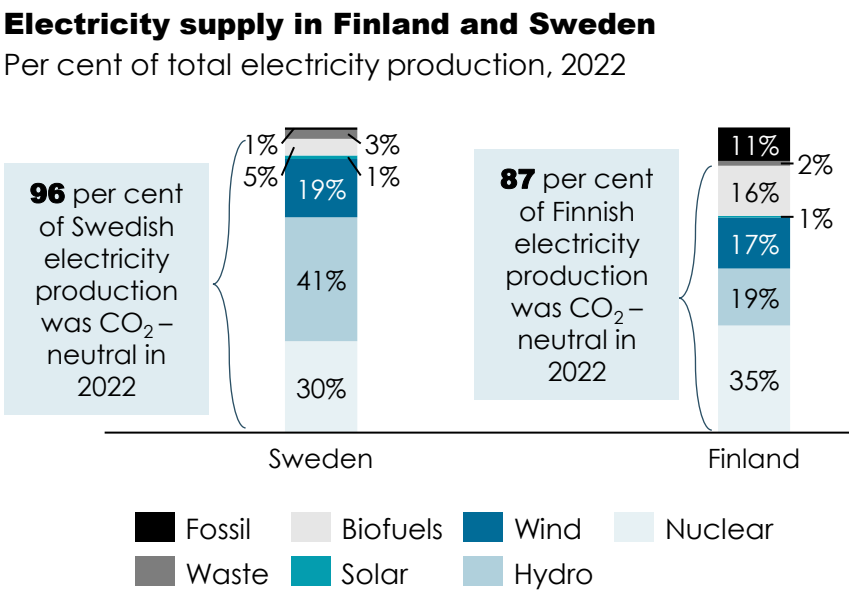
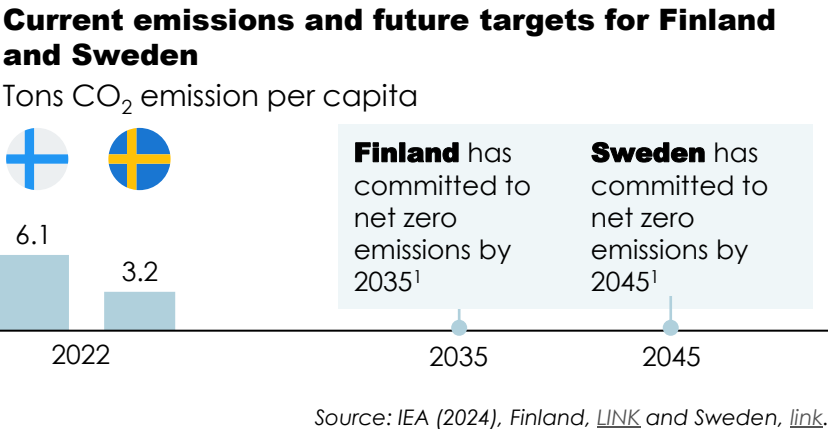
Introduction

Finland and Sweden aim to reach net-zero carbon emissions by 2035 and 2045¹, respectively.

In 2022, the CO₂ emissions per capita were 6.1 tons in Finland and 3.2 tons in Sweden², see the top figure. Consumption of fossil fuels is the main source for emissions in the Finnish and Swedish economies, primarily use of fossil fuels in transport and industry, but also for electricity production and heating. In 2022, 87 per cent of Finland's and 96 per cent of Sweden's electricity generation came from either renewable sources or nuclear power, see the bottom figure. The aim is for Finland's electricity generation to be nearly emission free before 2040³, and Sweden aims at producing all electricity with renewable sources or nuclear power by 2040.⁴

The power markets must achieve the decarbonisation whilst also handling increased demand from *direct electrification* and *indirect electrification*. Therefore, the transitions of the Finnish and Swedish economies require large investments into power supply, infrastructure, and demand-side electrification. Increased reliance on renewable energy will also create more volatility in the energy supply, creating a need for more demand- and supply-side flexibility. **We estimate electrification investments benefits** To uncover the benefits and costs of future electrification and market designs in Finland and Sweden, we take a

three-step approach, which also constitute the three chapters in the report: In **chapter 1**, we estimate the economic potentials from electrification investments using our global climate economic model INTERSECT, see next pages. With INTERSECT, we track the connections between different industries and countries to provide insights on the electrification value chain. In addition, we take into account the different politically set decarbonisation targets, as well as the international competition for attracting electrification investments. We calculate the future electrification investments' societal impact on value added, jobs, and taxes in Finland and Sweden in 2040. To qualify our estimations, we incorporate information from five interviews with industry stakeholders on investment decisions, and we estimate the economic impacts across three scenarios. In **chapter 2**, we analyse six instruments that can address challenges in an energy-only system in an assessment of an optimal long-term investment framework. We use desk research and information from the interviews to quantitatively and qualitatively evaluate the instruments' effectiveness in curbing risks and potentials, whilst also considering their costs to society. In **chapter 3**, we recommend a combination of market instruments based on the evaluation of which instruments, we expect deliver the highest societal benefits relative to their societal costs in Finland and Sweden, respectively.



1) In an update of the Finnish negative emission sink, the negative emissions were smaller than in previous estimations, see Helsinki Times (2023). In this work, we use the previous estimation. The Swedish target does not include existing LULUCF development. The target for other negative emissions is around 10 Mton CO₂e in 2045 from converting agricultural land to forest, BECCS, and payment for negative contributions in other countries. / 2) Including existing LULUCF. / 3) Ministry of Economic Affairs and Employment of Finland (2019), Finland's Integrated Energy and Climate Plan / 4) European Commission (2019), NECP factsheet Sweden.

Note: Coal, oil, natural gas, peat, and other sources are grouped in 'Fossil'. Fossil and waste are net CO₂ emitting supply in this figure (no CCS). Biofuels also emit CO₂ but is here considered net CO₂-neutral. Shares do not sum to 100 per cent due to rounding. Source: IEA (2024), Electricity Information, [link](#).

Fact box: INTERSECT maps connections across the electrification value chain

Introduction

In our global climate economic model INTERSECT, we model both **existing demand** for electricity and certain **new electricity demand**. *Existing demand* is already described in the underlying historic database of the model. As existing industries grow and households increase their income, they also increase their electricity demand. However, we assume that there will be increased energy efficiency, which limits this increase in electricity demand.

We capture *new electricity demand* by the rise of new industries (e.g., CO₂-free hydrogen) and when industries change their production methods, such as *direct* or *indirect electrification* of steel production.¹ Indirect electrification covers use of Power-to-X fuels, consisting primarily of renewable hydrogen, but also ammonia, methanol and sustainable aviation fuels (SAF).

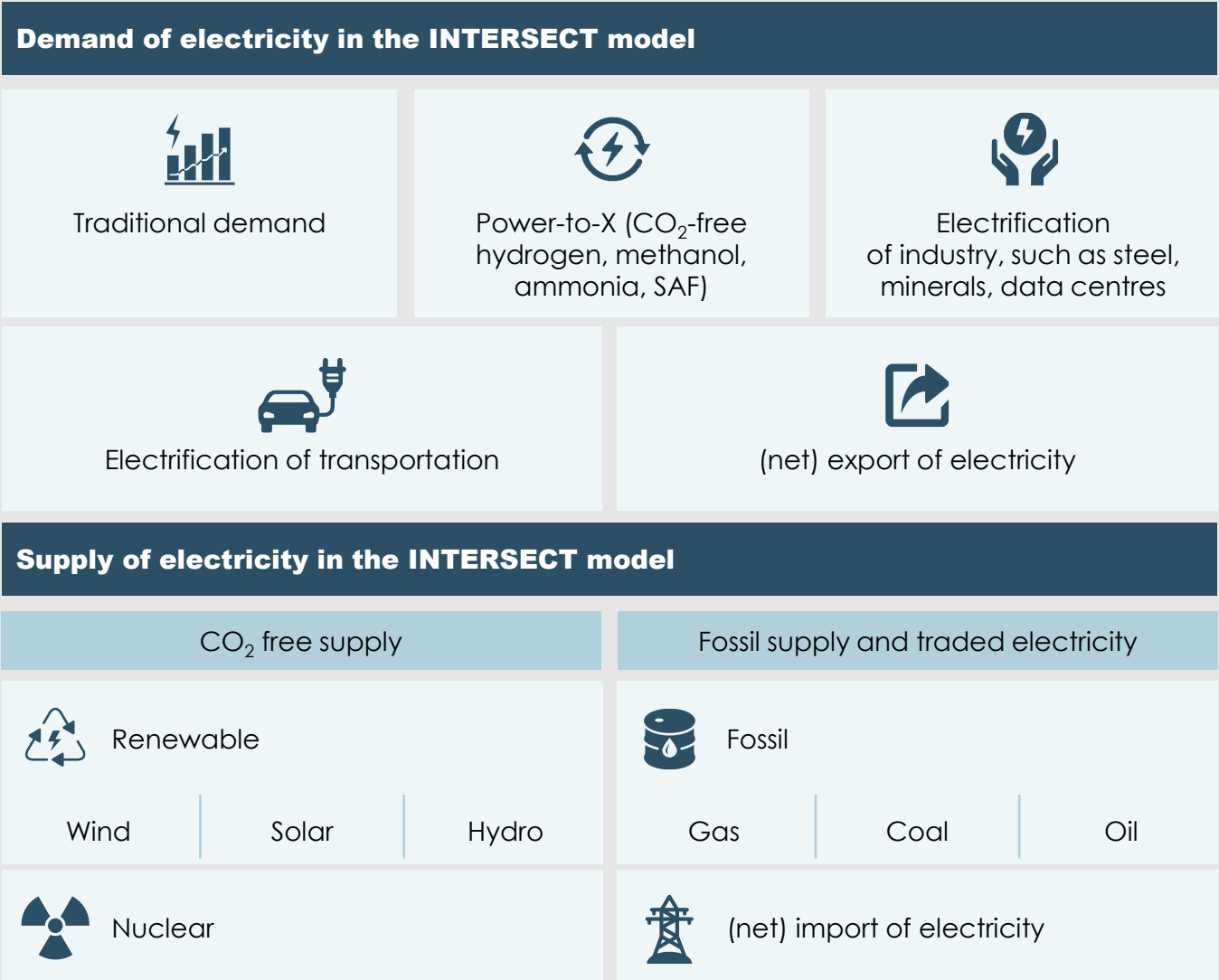
Electricity demand is determined endogenously in the model.² It is driven by the decarbonisation targets, household incomes, and electricity costs. Increased demand for electricity also generates more investment flows into supply-side electricity production.

INTERSECT includes electricity supply from several renewable sources, nuclear power, and fossil-based sources.

On adding new nuclear power in the electricity mix

In an energy-only system, new nuclear power is not cost-effective relative to other types of electricity generation based on a purely total-cost-of-ownership (TCO) cost approach in INTERSECT. However, nuclear power is one way to ensure stable electricity production. Therefore, nuclear power has merits from a system perspective. At the current cost levels, new nuclear power would require some sort of state aid to cover the capital costs to become operational.

To account for this, we include future nuclear investments using the forecasted plans from the Finnish and Swedish governments in our modelling.



1) In addition, we cover data centres, which are partially modelled in INTERSECT, but the investments are calculated outside of the model. / 2) INTERSECT uses an annual frequency. However, for the power market, annual frequencies are too crude as they ignore intra year price variation. In INTERSECT, renewable electricity uptake must be supplemented with storage capacity or non-intermittent technologies, such as nuclear or hydro power. Grid costs are included in INTERSECT but their underlying investments are not modelled explicitly.

Our analysis provides an outlook for how a decarbonised economy looks in Finland and Sweden, and the investments generated to get there

Introduction

	Insights offered by INTERSECT	• An understanding of what is needed for an economy to reach a certain decarbonisation target • The investments generated across different industries to reach a given decarbonisation target • How the sector composition changes when the economy decarbonises • What types of jobs are generated in the future – and which are not • The risks and opportunities of the green transition from a socio-economic point of view • The economic impacts of the green transition
	What INTERSECT does	• Considers a holistic, systemic view of the economy • Models industries' possibility to use different technologies in their decarbonisation efforts • Manages the combination of decarbonisation initiatives, politically set decarbonisation targets, and general macroeconomic development • Forces the economy to find economically optimal solutions to decarbonise according to the politically set targets
	What INTERSECT does not do	• Considers specific announced or pledged investments • Takes into account ad-hoc state-aid for single investments

SOCIETAL BENEFITS OF ELECTRIFICATION INVESTMENTS

Chapter 1

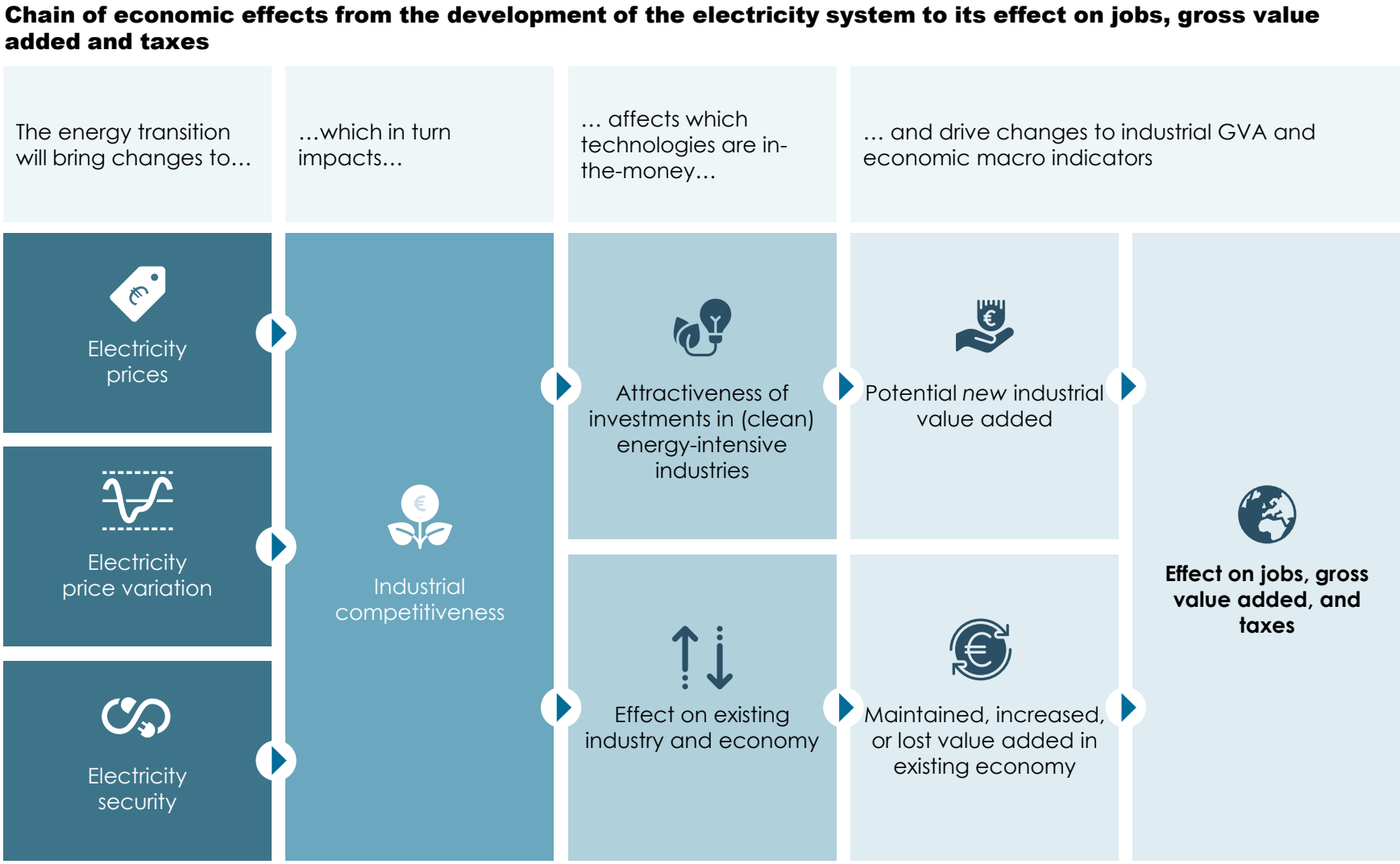
Electrification investments generate societal benefits through jobs, value added and taxes in Finland and Sweden

A strong electricity system improves industrial competitiveness, maintains existing industry, and attracts new industries

In this chapter, we estimate the societal benefits from electrification investments in terms of investment size, jobs, gross value added, and taxes. Electrification investments cover investments in processes or products that consume electricity (**demand-side electrification**) or produce CO₂-neutral electricity (**supply-side electrification**).

Electricity prices, price variation, and security of supply are key competitive parameters for where international companies place new electrification investments. These factors are critical for both attracting investments in new industries (e.g., Power-to-X), but also in maintaining existing industries that use (or will use) electricity in their production.

Over time, existing industries must decarbonise their production processes to stay competitive. However, some companies or industries will not be able to electrify cost-effectively, nor decarbonise their production in other ways, and will therefore exit the market in a decarbonised economy.



We estimate the *additional* economic benefits to the Finnish and Swedish economies from reaching decarbonisation targets

While there are politically set decarbonisation targets in Finland and Sweden, the speed by which the economies will transition to meet these may vary due to factors like climate policies, carbon pricing (e.g., ETS), etc. We capture these differences in three scenarios¹, see table:

1. A **delayed electrification (baseline) scenario** is built on the IEA stated policy scenario. In this scenario, no new climate policies are implemented. There are no immediate uptake of electrification across all industries. However, there will be increased electrification in areas where cost-effective solutions exist under today's energy-only market design, for example, electric vehicles and to some extent renewable energy production. The electrification is primarily driven by declining costs of certain green solutions and only to a

little extent by carbon prices, such as the EU ETS.

2. An **ambitious decarbonisation scenario** facilitates a faster and more ambitious decarbonisation, where more investments are made in both direct and indirect electrification. The scenario encapsulates the IEA net zero scenario and the politically set decarbonisation targets for Finland and Sweden for 2035 and 2045, respectively. Political actions are made to facilitate the transition towards a net zero-emission society. Therefore, electrification is *both* driven by cost-competitive green solutions *and* higher carbon prices that drive industries to decarbonise faster, using direct and indirect electrification. On top of this, we impose EU's production and import targets for CO₂-free hydrogen towards 2030.

3. An **electricity doubling scenario**, where Finland and Sweden double their respective electricity productions. This entails an electricity production of approximately 160 TWh in Finland and 300 TWh in Sweden by 2040, which is somewhat in line with government targets. The scenario results in more electrification investments than the two other scenarios, which will bring more economic benefits to Finland and Sweden from electrification.

The future electrification investments presented in this report are forecasts based on output from INTERSECT and cannot be directly compared to announced investments by individual companies. INTERSECT simulates the economy's expected decarbonisation path in response to politically defined electrification targets.

Three scenarios for electrification in Finland and Sweden towards 2040

Scenario	Electrification towards 2040	What needs to be true for the scenario to materialise?
Delayed electrification (baseline)	Electrification is slowly implemented in the coming years • Moderate direct electrification of light transport, some industry • Low indirect electrification	• No new regulatory development towards lowering emissions. • The transition is primarily driven by cost-competitive green solutions. • Global decarbonisation is built on the IEA stated policy scenario.
Ambitious decarbonisation	Electrification is taken up by most industries that consume energy • High direct electrification • Moderate-high indirect electrification	• Regulatory development towards lowering emissions through explicit or implicit carbon pricing. • Global decarbonisation is built on the IEA net zero scenario. • Finland and Sweden follow their national decarbonisation targets
Electricity doubling	Large scale deployment of electricity production lowers electricity prices which result in high direct electrification and high indirect electrification as well as increased export of energy or energy-intensive products.	• Same as for ambitious decarbonisation, but in addition: Political actions to double the electricity supply by 2040, which is a production of approximately 160 TWh in Finland and 300 TWh in Sweden.

1) We model these scenarios in our climate economic model INTERSECT. See Appendix C for a description of INTERSECT.
2) See Appendix A for more results for both scenarios.

Ambitious decarbonisation could lead to additional EUR 56 billion investments in Finland and EUR 42 billion in Sweden towards 2040

Ambitious decarbonisation leads to large additional investments in Finland and Sweden

We find that to reach its ambitious decarbonisation target, **additional EUR 56 billion** electrification investments are expected to be made in Finland from 2025 to 2040 relative to the delayed electrification scenario, see figure. EUR 25 billion of the additional investments in Finland are in supply-side electricity production to supply more electricity in the economy. In total, electrification investments reach EUR 178 billion in investments in an ambitious decarbonisation scenario.

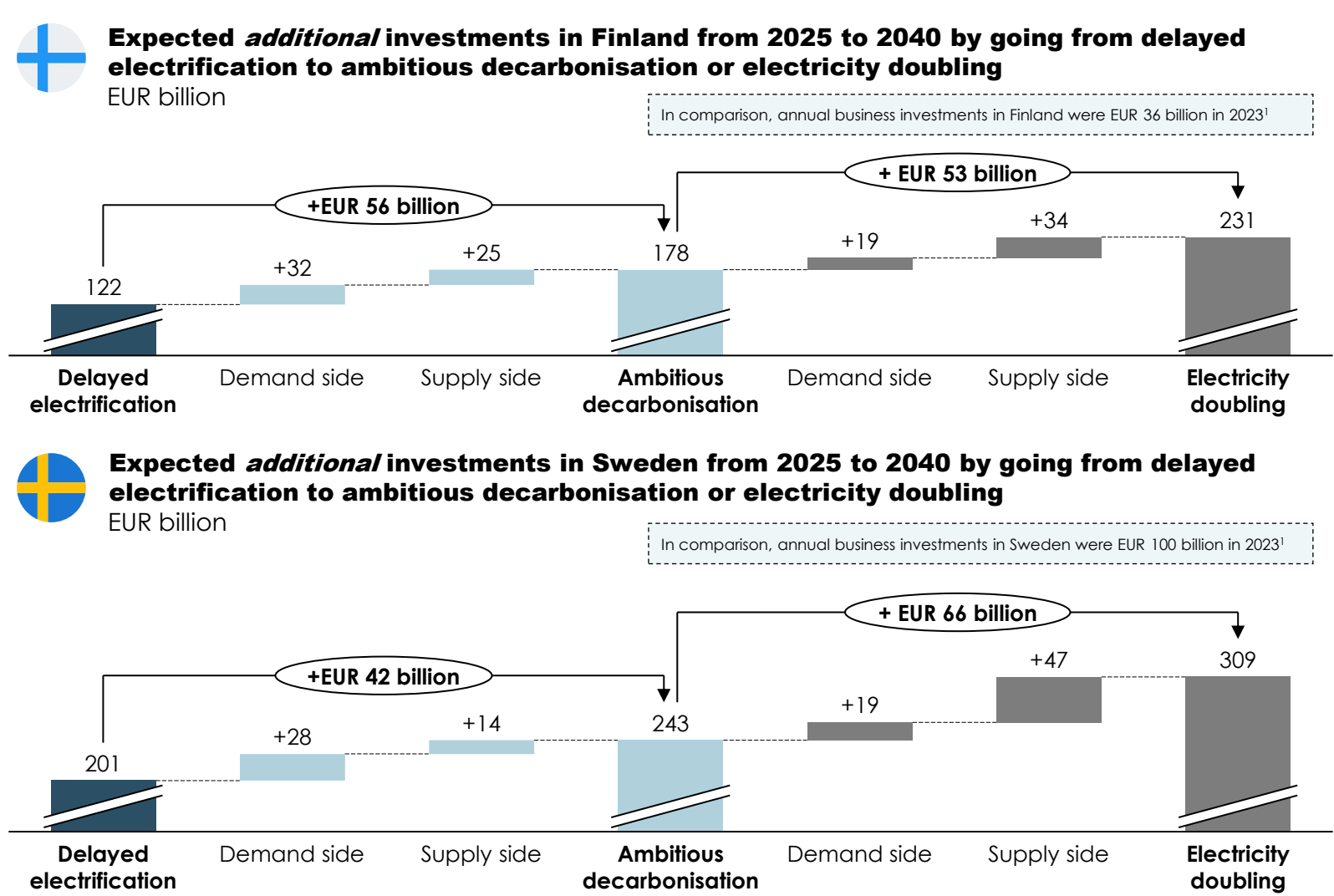
The demand-side investments will primarily be made in personal EVs, but also electrification of freight, mining, minerals, metals, hydrogen, and datacentres.

Should Finland reach an electricity doubling scenario², **additional EUR 53 billion** investments are expected towards 2040 *on top of the decarbonisation scenario*.

In Sweden, investment potentials are **EUR 42 billion** higher in an ambitious decarbonisation scenario than in the delayed electrification scenario, totalling EUR 243 billion investments towards 2040. EUR 14 billion *additional* investments in supply-side electricity production are expected in Sweden.

The higher *additional* investments generated in Finland (+EUR 56 billion vs. +EUR 42 billion) is driven by Finland's more ambitious decarbonisation plan towards 2040.

Should Sweden reach the set target of a doubling of its electricity production², **additional EUR 66 billion** investments are generated towards 2040.



Note: The numbers do not add up to the totals due to rounding. 2021-prices.
Source: Copenhagen Economics based on INTERSECT.

1) Eurostat (2024), GDP and main components (output, expenditure and income) and Eurostat (2024), Investment share of GDP by institutional sectors / (2) In this scenario, we set the Finnish electricity production to reach 160 TWh in 2040, and Sweden to reach 300 TWh. See Reuters (2022): Swedish power demand could double by 2035 amid electrification drive and Finnish Government (2023): Minister Mykkänen: Excellent opportunities for Finland to become major player in clean energy / 3) Oxford Economics (2024): Assessing the Macroeconomic Impact of EU climate policy on Finland's economy.

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Societal benefits arising from electrification investments include jobs, gross value added, and taxes

On the next pages, we show the economic potentials that are supported by electrification investments in Finland and Sweden. These potentials cover **jobs**, **gross value added** and **taxes**, see descriptions below. As Finland and Sweden electrify their economies, more people will be employed in high-productive electrified industries. The people that are employed in these industries earn wages and generate profits to the sector, which in turn provide taxes to the Finnish and Swedish public finances. Some industries (for example fossil fuel industries) will see a decline in economic activity when the country decarbonises, resulting in fewer jobs, gross value added, and taxes in these industries.

Jobs

We cover jobs for the number of people that are *directly* employed in industries that

- **Produces electricity** (supply-side) or
- **Have electrified their processes** (demand-side)

A person with a job in a steel mill that **has** electrified production **is** included, and a person with a job in a steel mill that **has not** electrified its processes **is not** included.¹

Our job estimates cover jobs to maintain and operate the new industry. We **do not** include *indirect* jobs in the value chain, from suppliers of electricity to users of electricity, or jobs created in the construction phase, as these would be highly uncertain for new industries, see table.²

Gross value added (GVA)

GVA consists of two components :

- **Labour compensation**, which covers gross salary and other payments to employees
- **Return on capital**, which covers company profits.

GVA is closely related to GDP, but GVA does not include production taxes and subsidies, which are included in GDP.

We assume that the people employed in electrified industries will become more productive over time, meaning that each job will produce higher average GVA over time.

Taxes

We cover tax payments of the gross value added. These cover:

- **Income taxation**³ of labour compensation based on average income tax rates in Finland and Sweden, respectively.
- **Corporate taxation**³ of company profits, represented by taxation of the return on capital in Finland and Sweden.

We do not cover **production taxes**, which include energy taxes, CO₂ taxes, and product taxes. This is due to the uncertain future regulation of these taxes, as the tax base may shrink with increasing electrification. For example, in Finland there is currently no tax on EVs⁴, but this may change in the future as public revenues from taxation of fossil-fuel cars decline.

Type of effect	Included?	Description
Direct	✓	We include the direct economic activity pertaining to the operation of the industry that has electrified their operations.
Indirect	✗	The import share for inputs into the production is essential to calculate indirect multipliers. For new industries, this import share is highly uncertain. Therefore, we do not include indirect jobs, GVA and tax.
Induced	✗	Same argument as to indirect effects

1) For this reason, we classify the jobs as **supported** by the electrified industries, which means that the jobs are not *necessarily new created* jobs in the economy. / 2) For example, this means that we do not include jobs in the construction phase of building a Power-to-X plant, nor do we any *induced jobs* (hotels, housing, restaurants retail) that arise from economic activity. 3) Subject to constant tax rates. / 4) See YLE (2024), *An EV revenue hit*.

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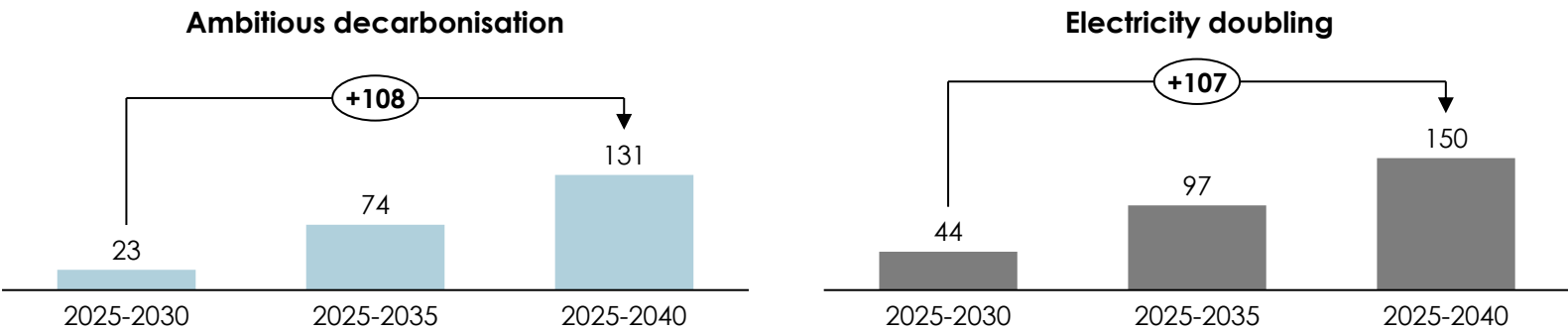
A wide-angle photograph of the Helsinki skyline. The Helsinki Cathedral, a large white neoclassical building with a prominent green copper dome and smaller domes, stands as the central focus in the background. Below it, a row of colorful, multi-story buildings in shades of white, pink, and yellow lines the waterfront. In the foreground, the harbor is visible with several boats, including a white ferry with 'MarivaLi' written on its side, and a busy pier with people and vehicles. The sky is filled with soft, grey clouds, suggesting an overcast day.

FINLAND

SOCIETAL BENEFITS OF ELECTRIFICATION INVESTMENTS

For an ambitious decarbonisation, EUR 131 billion of demand-side electrification investments are generated in Finland towards 2040

Cumulative investments in demand-side electrification
EUR billion



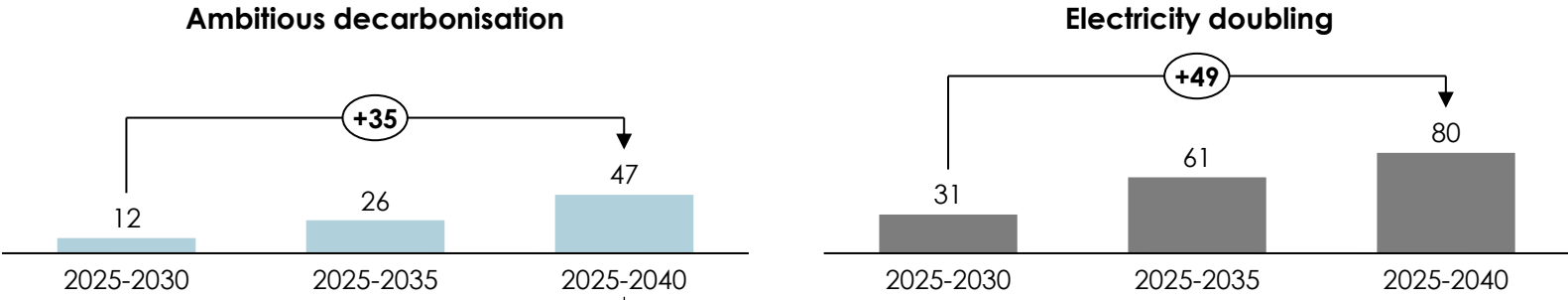
In an ambitious decarbonisation, large investments are generated in Finland

Out of the EUR 178 billion investment generated in an ambitious decarbonisation scenario towards 2040, demand-side electrification investments amount to **EUR 131 billion**, see figure. Demand-side investments only reach EUR 23 billion towards 2030, but after 2030, the investment size grows by EUR 108 billion from 2030 to 2040, see figure.

Demand-side investments are made to support the electrification in different industries, including hydrogen, steel and other metals. Most investments are made in personal EVs, as the personal car fleet is replaced with electric vehicles over time.

Realising these demand-side investments generates supply-side investments in electricity generation of **EUR 47 billion** towards 2040, plus grid investments.

Cumulative investments in supply-side electrification
EUR billion



More investments are generated to reach electricity doubling

In an electricity doubling scenario, we find that demand-side electrification investments of **EUR 150 billion** and supply-side electrification investments of **EUR 80 billion** are generated in Finland towards 2040.

In addition, transmission grid investments amounts to EUR 5.5-7 billion from 2025-2040 based on a volume-adjusted extrapolation of Fingrid's plan for 2024-2033.³

Note: The numbers do not add up to the totals due to rounding. 2021-prices.
Source: Copenhagen Economics based on INTERSECT.

1) Autoalan Tiedotuskeskus (2024), *Henkilöautokannan keski-ikä eräissä Euroopan maissa*. / 2) International Organization of Motor Vehicle Manufacturers (2020), *World Vehicles in use*. / 3) Fingrid (2023), *Fingrid's main grid development plan provides for increased investments to promote Finland's competitiveness*. / 4) Oxford Economics (2024): *Assessing the Macroeconomic Impact of EU climate policy on Finland's economy*. / 5) BCG (2022), *Finland's path to Net Zero*.

In an ambitious decarbonisation scenario, electrification supports an additional 61,000 jobs and EUR 14 billion in GVA in Finland in 2040

Electrification investments support thousands of high productive jobs in Finland

In an ambitious decarbonisation scenario, direct and indirect electrification and related electricity generation could support an additional **61,000 jobs**¹ in 2040, relative to the current levels.² This is 19,000 more jobs than in delayed electrification, see figure. Further 9,000 jobs could be achieved in a double electrification scenario towards 2040.

Electrification investments enable a transition in the labour market away from jobs in industries relying on fossil fuels to jobs in green industries.

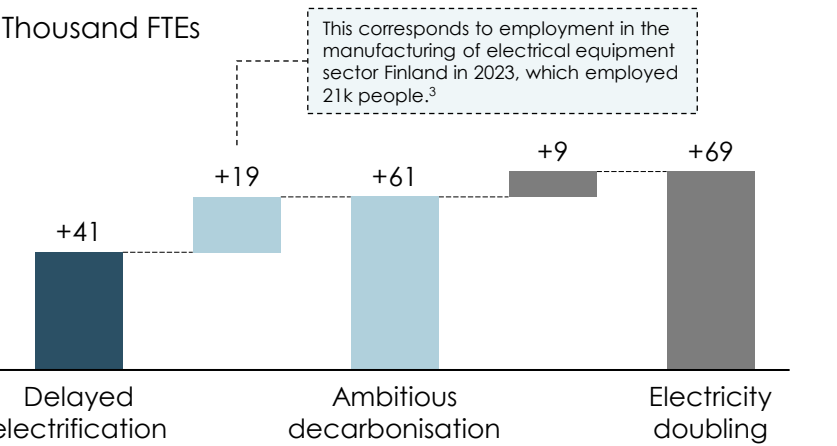
Jobs in green industries are high-productive jobs with high value added to the Finnish economy. Additional value added in these industries amounts to almost **EUR 14 billion** in 2040, relative to current levels. This is EUR 4.7 billion more than in delayed electrification. In electricity doubling, additional EUR 3.2 billion is expected in GVA.

The electrified industries in Finland have a high GVA per job, as the industries are relatively capital-intensive, and the labour productivity is high. This means that the economic output per job is higher than for an average job in Finland, and these jobs will therefore boost the Finnish economy, all else equal.

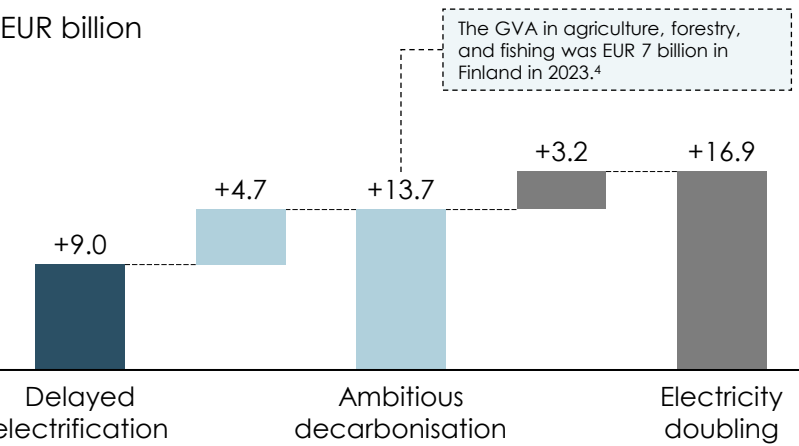
The electrified industries also generate tax revenue for Finnish public finances from income and corporate taxation, concretely **EUR 3.4 billion** in 2040, EUR 1.1 billion more than in delayed electrification. In the electricity doubling scenario, we expect an additional EUR 0.7 billion in taxes towards 2040.

The tax payments are closely linked to the size of the gross value added as we cover taxation of wages and company profits which make up the gross value added- This means that the Finnish public finances also benefit from the high productivity in the electrified industries.

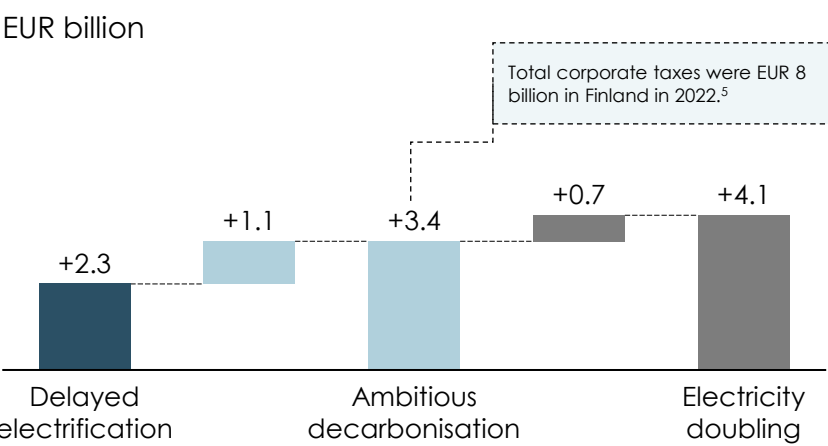
Jobs from electrification in 2040, relative to current levels²



Gross value added from electrification in 2040, relative to current levels²



Taxes generated from electrification in 2040, relative to current levels²



Note: The numbers do not add up to the totals due to rounding. Taxes include corporate taxes and income taxation, based on the remuneration of labour and capital from the value added, and the average tax rates in Finland. 2021-prices. Source: Copenhagen Economics based on INTERSECT.

1) Note that this is likely conservative since we do not include indirect effects and jobs in the construction phase. / 2) Current levels are based on 2021 inputs. / 3) Eurostat (2024), *Employment by sex, age, professional status and full-time/part-time* / 4) Eurostat (2024), *Gross value added and income by A*10 industry breakdowns* / 5) Eurostat (2024), *Main national accounts tax aggregates*



SWEDEN

SOCIETAL BENEFITS OF ELECTRIFICATION INVESTMENTS

For an ambitious decarbonisation, EUR 203 billion of demand-side electrification investments are generated in Sweden towards 2040

In an ambitious decarbonisation, large investments are expected in Sweden

Out of the EUR 243 billion investment generated in an ambitious decarbonisation scenario towards 2040, demand-side electrification investments amount to **EUR 203 billion**. The investments towards 2030 reach EUR 24 billion, but after 2030, the investment size grows and almost EUR 180 billion more is expected from 2030 to 2040.

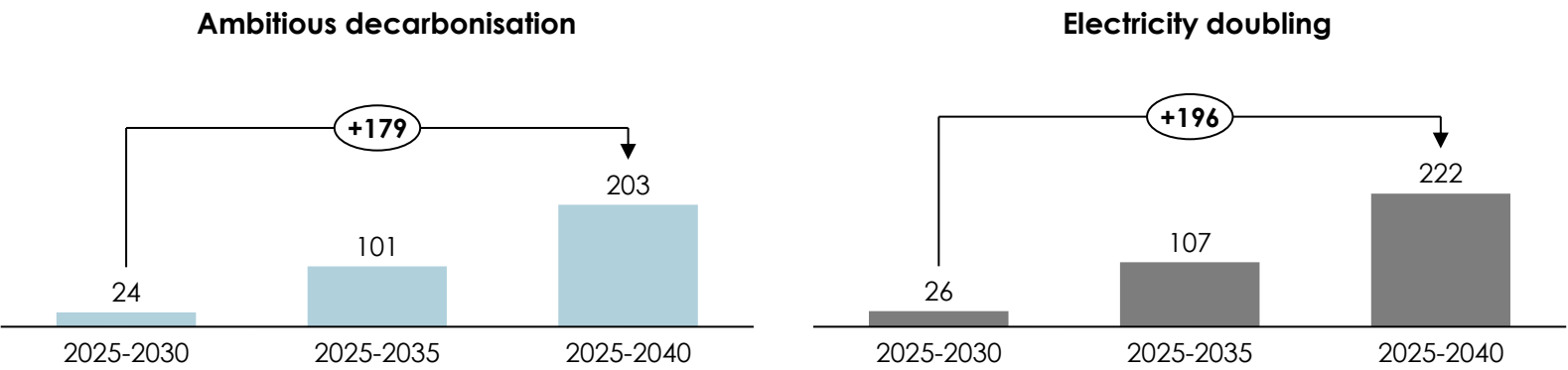
Demand-side investments are made to support the electrification in different industries, including hydrogen, steel and other metals. Most investments are made in personal EVs, as the personal car fleet is replaced with electric vehicles over time.

Realising these benefits generates supply-side investments in electricity generation of **EUR 40 billion**, which is EUR 14 billion higher than in a delayed electrification scenario.

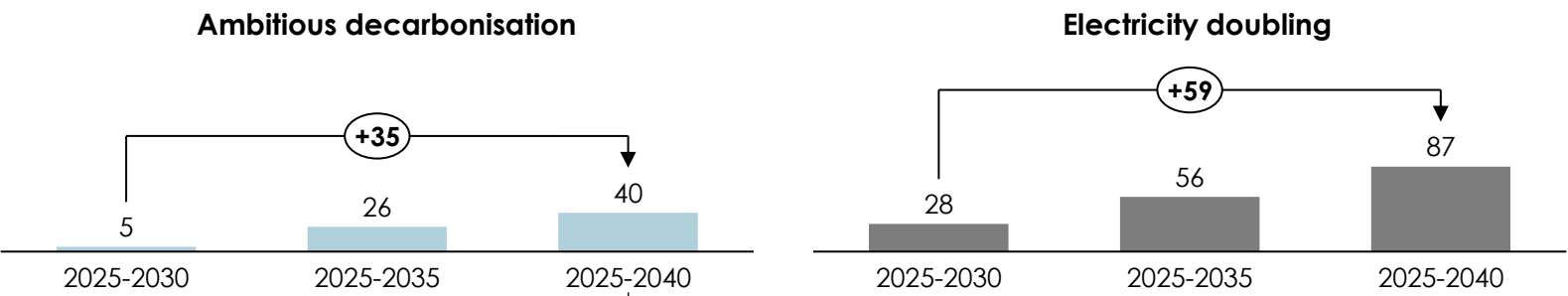
More investments are generated to reach electricity doubling

In an electricity doubling scenario, we find that demand-side electrification investments of **EUR 222 billion** and supply-side electrification investments of **EUR 87 billion** are generated in Sweden towards 2040.

Cumulative investments in demand-side electrification
EUR billion



Cumulative investments supply-side electrification
EUR billion



Grid investments are not included. Transmission grid investments could be in the range EUR 15-20 billion from 2025-2040 based on extrapolated and volume-adjusted annual investments³ One estimate suggests that DSO grid investments in Sweden will be EUR 16 billion in the period 2020-2030.⁴

Note: The numbers do not add up to the totals due to rounding. 2021-prices.
Source: Copenhagen Economics based on INTERSECT.

1) Autoalan Tiedotuskeskus (2024), *Henkilöautokannan keski-ikä eräissä Euroopan maissa* / 2) International Organization of Motor Vehicle Manufacturers (2020), *World Vehicles in use* / 3) Based on Ember (2024), *Putting the mission in transmission: Grids for Europe's energy transition* / 4) Monitor Deloitte (2021), *Connecting the dots: Distribution grid investment to power the energy transition* / 5) BCG (2022), *Sweden's path to Net Zero*

In an ambitious decarbonisation scenario, electrification supports an additional 68,000 jobs and EUR 18 billion in GVA in Sweden in 2040

Electrification investments support thousands of high productive jobs in Sweden

In an ambitious decarbonisation scenario, direct and indirect electrification and related electricity generation could support an additional **68,000 jobs**¹ in 2040, relative to the current levels.² This is 19,000 more jobs than in delayed electrification, see figure. A further 24,000 jobs could be achieved in a double electrification scenario towards 2040.

Electrification investments enable a transition in the labour market away from jobs in industries relying on fossil fuels to jobs in green industries.

The jobs in these industries are high-productive jobs with high value added to the Swedish economy. The additional value added in these industries amounts to almost **EUR 18 billion** in 2040, relative to current levels. This is EUR 3.8 billion more than in delayed electrification. In electricity doubling, additional EUR 5.4 billion is expected in GVA towards 2040.

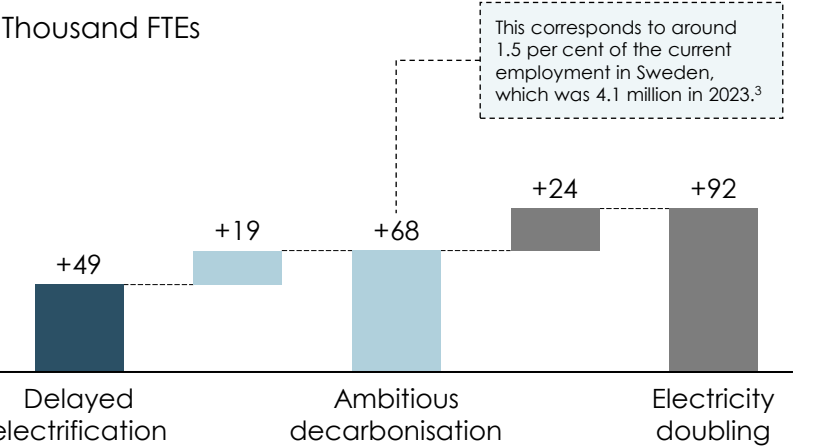
The average GVA per job in electrified industries is similar to Finland. The electrified industries in Sweden have a high GVA per job as the industries are relatively capital-intensive, and the labour productivity is high in these industries. This means that the economic output per job is

higher than the average job and these jobs will therefore boost the Swedish economy, all else equal.

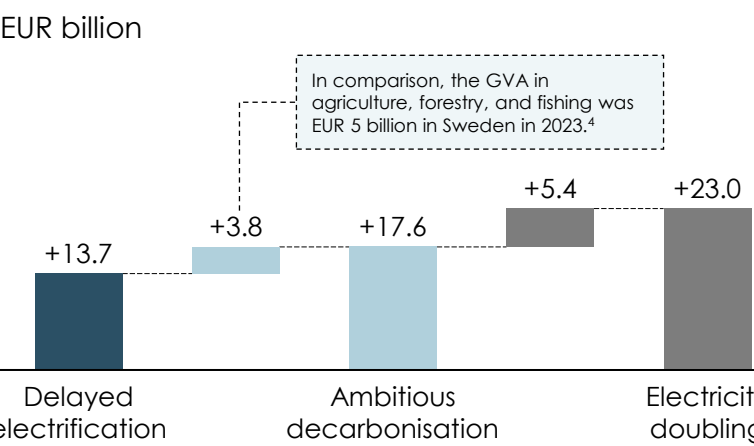
Swedish public finances will also get revenue from income and corporate taxation, concretely **EUR 4.3 billion** in 2040, EUR 1.0 billion more than in delayed electrification. In electricity doubling, additional EUR 1.3 billion is expected in taxes from electrified industries in 2040.

The tax payments are closely linked to the GVA as it is taxation of labour compensation and company profits, so the Swedish public finances also benefit from the high productivity in the electrified industries.

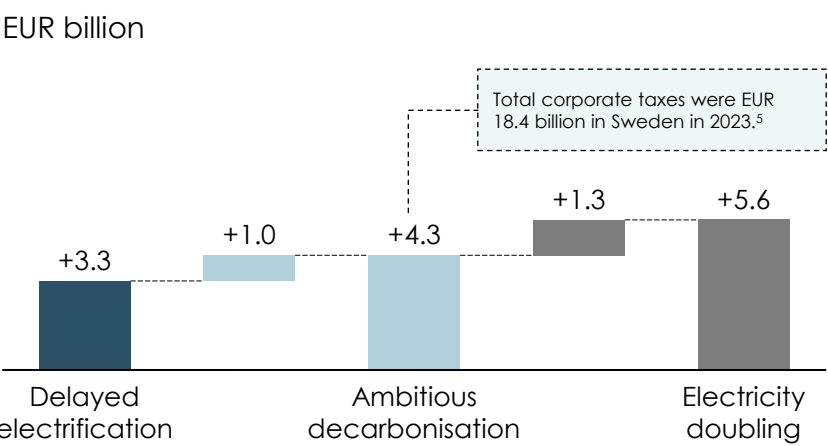
Jobs from electrification in 2040, relative to current levels²



Gross value added from electrification in 2040, relative to current levels²



Taxes generated from electrification in 2040, relative to current levels²



Note: The numbers do not add up to the totals due to rounding. Taxes include corporate taxes and income taxation, based on the remuneration of labour and capital from the value added, and the average tax rates in Sweden. 2021-prices. Source: Copenhagen Economics based on INTERSECT.

1) Note that this is likely conservative since we do not include indirect effects and jobs in the construction phase. / 2) Current levels are based on 2021 inputs. / 3) Eurostat (2024), *Employment by sex, age, professional status and full-time/part-time* / 4) Eurostat (2024), *Gross value added and income by A*10 industry breakdowns* / 5) Eurostat (2024), *Main national accounts tax aggregates*.

A MARKET DESIGN OPTIMISING THE LONG- TERM INVESTMENT FRAMEWORK

Chapter 2

Investment risks must be lowered to fully unlock potential social benefits from demand-side electrification

In the previous chapter, we established that Finland's and Sweden's economies could gain immensely from ambitious decarbonisation and electrification investments towards 2040. For these investments to materialise, the investment cases must be commercially and financially viable, *throughout the value chain*, see below.

An investor expects a return on investment corresponding to the risk of a given investment. Uncertainty, of whatever nature and source, around the future business case for an investment, translates into risk, e.g., market risk, political risk, or technical risks. All sources of risk drive up the required return on a given investment. In turn, this increases the **cost of capital for investors**, challenging the commercial viability of the business case. As a result, investors face a higher risk of their assets being stranded¹, which may end up deterring investments all together. This is for example the case for investments in demand-side electrification and corresponding electricity supply identified in the previous chapter.

Value chain from energy production to final demand

Supply-side: Electricity production

- Solar
- Wind
- Hydro
- Nuclear
- Biomass CHP
- Waste CHP

In this chapter, we move to **identify and analyse some of the more potent risks and challenges** that we believe may deter future demand-side electrification investments in Finland and Sweden if not countered by e.g., policies to ensure a conducive long-term investment framework.

Based on responses from interviews² with existing and potential future electricity consumers and from reports by the Finnish and Swedish TSOs³, we highlight the challenges in the current energy-only market design.

We find that there is **a need to change the current energy-only power market design to lower risks for demand-side electrification investors and corresponding supply-side investments**. If these challenges are not addressed, Finland and Sweden risk falling short of the full societal benefits from demand-side electrification.

A new design shall aim to ensure a stable environment for companies to invest and thus enable the demand-side electrification investments and the corresponding supply-

Infrastructure: Transmission, and distribution

- TSO and DSO grids
- Interconnectors
- Infrastructure for CO₂, green H₂ and other PtX products

side investments.

We identify a gross list of 11 political and market instruments that have relevance in a Finnish, Swedish or European context. From this list, we select the six instruments deemed most effective in mitigating the challenges in the current system, at a reasonable cost.

We analyse the societal benefits and costs of the six instruments, which we then use for our recommendation in chapter 3. We analyse these instruments on a general level, as the specific design of each instrument would have to be carefully planned and designed, if implemented.

In our assessment of the six instruments, we consider the **value chain from energy production to final demand** and the associated risks in various parts of this chain, see below. We also consider how public sector finances are impacted by adoption of such instruments on a stand-alone basis.

Demand-side: Final demand

- Traditional demand
- Direct electrification
- Indirect electrification using e-fuels from Power-to-X
- Flexibility and energy management

1) Stranded assets are physical assets that companies have invested in that becomes redundant, for example due to market or regulatory development. / 2) We interviewed stakeholders within paper and pulp, mining, metal production, and Power-to-X. See Appendix C / 3) Svenska Kraftnät (2023), *A future capacity mechanism to ensure resource adequacy in the electricity market*, and AFRY (2023), *Assessment of future capacity solutions to ensure resource adequacy in the Finnish electricity market*

Note: In addition, Energy markets facilitate the market through wholesale markets, intraday and next day market, balancing market, flexibility, and non-market mechanisms.

Risks unaccounted for in current market designs may deter demand-side investments

We identify five groups of challenges along the value chain that are not mitigated in the current energy-only market design; namely price risk, timing risk, capacity adequacy risk, counterparty risk, and institutional risk.

Price risk: Capture prices in the electricity market is key for supply-side investments. In recent years, Sweden and especially Finland have had lower electricity prices compared to the EU average¹. With more intermittent energy, the risk of cannibalisation increases, such that captured prices, for example for wind, are too low to ensure a profitable business case. In a simulation of the future electricity markets in Finland and Sweden, we find lower expected capture prices for wind as the share of wind in the electricity mix increases.²

Timing risk^{3,4}: For both supply-side and adequacy demand-side investors, access to the grid is essential. However, there are limitations to how fast grid networks can be built given regulatory and technical

constraints. Similarly, the timing between new electricity supply and demand may be misaligned, making it difficult to bring projects to final investment decisions.

Capacity adequacy risk⁵: For final demand, stable (and low) electricity prices, and adequate capacity are important drivers of investments. Increasing demand and more intermittent energy in the system will increase the risk of imbalances in an energy-only market, as highlighted in reports by the Finnish and Swedish TSOs.⁶ Too low capacity in certain periods (e.g., cold winters) results in periods of high prices and high price volatility. Increase in intermittent energy and varying gas prices have already led to higher volatility in the electricity price, in some instances with negative prices and other times with high prices.⁷

Some supply-side participants also benefit from price volatility, for example batteries, but price volatility can be problematic for certain demand-side electrification investors that cannot operate flexibly in the market.

Counterparty risks: Both supply-side and demand-side investors typically need a fixed price from power purchasing agreement (PPA) to be able to bring their project to a final investment decision. However, PPAs come with counterparty risks, as it is not certain that the user is able to pay for the electricity generated. Therefore, financial backing is important, but long-term financial backing is difficult to achieve for new, unproven demand-side industries, which increases the counterparty risk from PPAs for supply-side investors.

Institutional risks: Changes to overall framework conditions like underlying fundamentals, regulation, tariffs etc. creates uncertainty. Examples include frequent changes to taxation, long and arduous permitting procedures, and cost of access to grid. To the average investor, it might matter less what the exact framework conditions are in terms of, say, taxes etc. – as long as they are stable and predictable. In our interviews and from desk research, we have identified this to be a concern in Sweden.⁸

Challenges across the value chain in Finland and Sweden and numbers for the six selected instruments (see next page)

Supply-side: Electricity production		Infrastructure: Transmission and distribution		Demand-side: Final demand	
Price risk	4 5	Timing risk	1 6	Capacity adequacy risk	2 3 4 5
Counterparty risk	4 5	Counterparty risk	4 5	Counterparty risk	4 5
Institutional risk	1 2 3 6	Institutional risk	1 2 3 6	Institutional risk	1 2 3 6

1) Eurostat (2024), Electricity prices for household consumers - bi-annual data (from 2007 onwards) / 2) See appendix C. / 3) YLE (2023), Sähköön siirtohintoja valvovan mallin muutos kuohuttaa verkkoyhtiöitä – kuluttajahinnat tuskin kovin nopeasti laskevat / 4) Valtioneuvosto (2023), A strong and committed Finland: Programme of Prime Minister Petteri Orpo's Government / 5) Fingrid (2023), Fingrid's electricity system vision 2023 and Fingrid(2024), Sähköön tuotannon ja kulutuksen kehitysnäkymät: Fingridin ennuste Q1/2024 / 6) Svenska Kraftnät (2023), A future capacity mechanism to ensure resource adequacy in the electricity market, and AFRY (2023), Assessment of future capacity solutions to ensure resource adequacy in the Finnish electricity market 7) For example, in Finland on January 5th, 2024, the peak electricity price was 2,351€ per MWh, which was nearly 18 times the average price, see sahkoa.io (2024) / 8) See appendix C and RECHARGE. (2024). Stuck: 35GW red tape backlog threat to Sweden's offshore wind boom, and EnergyWatch. (2023). Statkraft receives rejection for double-approved wind farm. Copenhagen Economics

A deep-dive into six instruments

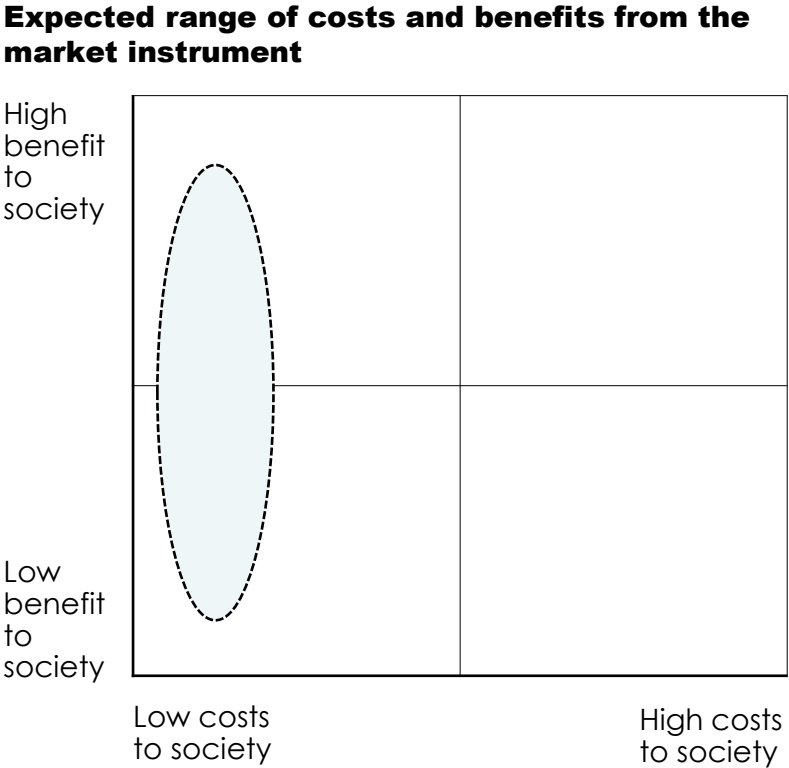
Gross list of political and market instruments and the six selected instruments, *which are examined on the next pages and in Appendix B*

	Instrument	Mitigation of risks	Relevance	Reason for de-selection	Short description
Political	Stable political environment 1	Institutional and timing	Changing political majorities and priorities have increased investment uncertainty in Sweden. ¹		A stable political environment means that long-term political plans are implemented with broad political backing, so that they remain stable - also with changing political majorities.
	Market-wide capacity remuneration mechanism (CRM) 2	Institutional and capacity adequacy	CRMs are being discussed in both Finland and Sweden. Some interviewees noted that they could provide demand-side flexibility. ²		CRM covers flexible demand and supply capacity that is remunerated for obligated availability in the market to deal with seasonal, weekly, daily or hourly imbalances, typically in long-term contracts.
Adequacy and flexibility	Non-fossil flexibility support scheme (type of CRM) 3	Institutional and capacity adequacy	Non-fossil flexibility support scheme is mentioned in the recent EU electricity market design agreement. ³		This type of CRM covers demand-side flexibility, batteries, and new, CO ₂ -neutral power generation capacity that is remunerated for being obligated available in the market to deal with seasonal or short-term imbalances, typically in long-term contracts.
	Energy communities	Capacity adequacy	The EU has an ambition to increase the uptake of local flexibility in energy communities. ⁴	Can help alleviate the investment need in the grid, but it is uncertain to what extent it will be taken up, even with new regulation enabling communities.	Groups of individuals or organizations that aim to increase energy self-sufficiency by collaborating to produce, consume, and manage energy, using own renewable sources and operating own internal grids within the community.
State aid or user payment	Publicly-backed power purchasing agreements (PPA) 4	Price, capacity adequacy, counterparty	Publicly-backed PPAs are mentioned in the recent EU electricity market design agreement. ³		The government insures an agreement for electricity purchases (PPAs) between an electricity supplier and electricity demanders, perhaps against an insurance fee. In case of default, the government pays the supplier for losses incurred.
	Contracts-for-Difference (CfD) auctions 5	Price, capacity adequacy, counterparty	Two-way CfDs are mentioned in the recent EU electricity market design agreement. ³		Two-way CfDs are financial agreements that provide payments to CO ₂ -neutral power generators for the difference between the market price of electricity and a predetermined strike price. These are typically used for offshore wind or nuclear power.
	Regulatory asset base (RAB)	Price and capacity adequacy	Used for nuclear power in the UK. ⁵	Public payments through a regulatory asset base can ensure revenue for supply-side investments but will require a cumbersome system for managing the regulation.	RAB is the value of a regulated utility's assets on which it is allowed to earn a specified (regulated) rate of return on invested capital paid by the government or by users.
	Direct subsidies	Price and capacity adequacy	Direct subsidies in energy markets already exist in the EU and in several member states. ⁶	Direct subsidies are already present for example through the Hydrogen Bank. ⁶	The government provides direct subsidies to specific energy producing assets. Such subsidies can be provided directly to the supply-side or the demand-side (subject to EU state aid regulation).
Infrastructural planning	Geographically differentiated tariffs 6	Institutional and timing	Fingrid has discussed implementing such tariffs. ⁷ Grid bottlenecks are not evenly distributed across geographies. ⁸		Refer to differentiated tariffs provided to incentivise grid connections and/or production or consumption of electricity in specific areas. Can be used as a less intrusive alternative to price zones.
	Cross-border interconnectors	Capacity adequacy and timing	Both countries are investing in interconnectors. ⁹	Cross-border interconnectors are already now being planned or developed.	Interconnectors are built to exchange electricity between countries and can help stabilise electricity prices.
	Power-to-X infrastructure investments	Institutional and timing	Gasgrid and Nordion Energi are examining the possibility for hydrogen pipelines. ¹⁰	Power-to-X infrastructure is already now being planned or developed to some extent.	Government support for infrastructure for Power-to-X such as port infrastructure or hydrogen pipelines.

1) Information from interviews / 2) AFRY (2023), *Assessment of future capacity solutions to ensure resource adequacy in the Finnish electricity market*; AFRY (2024), *How firm and flexible capacity supports Finland to become a green superpower*; Svenska Kraftnät (2023), *A future capacity mechanism to ensure resource adequacy in the electricity market*. / 3) European Commission (2023), *Commission welcomes deal on electricity market reform*. / 4) European Commission, *Energy communities*. / 5) UK Gov (2022), *Development costs and the nuclear Regulated Asset Base (RAB) model* / 6) European Commission, *European Hydrogen Bank* / 7) Fingrid (2024) *Muutosehdotuksia kantaverkkomaksujen Rakenteeseen* 8) See for example AFRY (2019), *Grid Capacity Challenges in Sweden* and IEA (2023), *Finland 2023 – Energy Policy Review* / 9) Baltic Wind (2022), *Fingrid will invest €3 billion in the transmission network. New cross-border connections planned* / 10) Gasgrid (2022), *Nordic Hydrogen route*.

Instrument 1: A prerequisite for a strong long-term investment framework is a stable political environment

Scope of the instrument	Frequent changes to legislation increase the uncertainty for investors. For example, political changes as to who pays for offshore wind grid connections in Sweden have increased uncertainty.¹ Similarly, the political stance on nuclear power in Sweden has been unclear for several years.² By providing a stable long-term political framework, investors know what to expect for the future and that the outlook of their investment will not change from one government to the next.
Societal benefits: LOW - HIGH	Political certainty lowers the risk for long-term investments, which also lowers the cost of capital (or required return) for investors. Lower cost of capital will – all else equal – make more investments profitable, resulting in more electrification investments. In countries where there already is a relatively stable political environment, additional societal benefits from increased political certainty are expected to be low.
Societal costs: LOW	There is a risk of political lock-in in the selection of specific technologies. For example, if a too ambitious target is set for a specific technology, the government may end up choosing expensive, sub-optimal decisions to achieve the target, even if other solutions are more societal beneficial relative to their costs. If the political targets are set realistically, these risks are expected to be low.



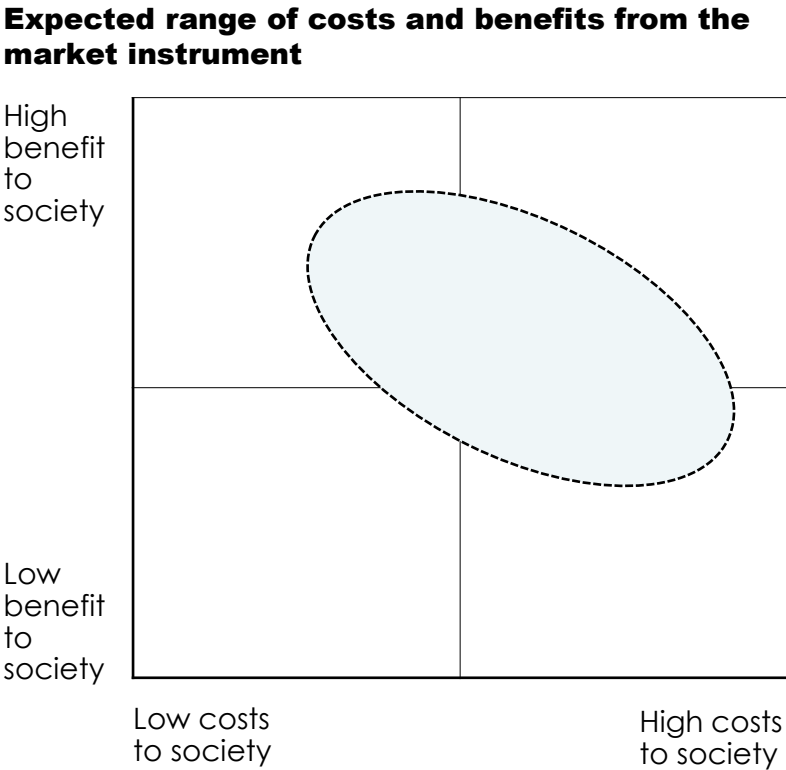
Note: The figure is an illustration of what we expect the societal costs and benefits are. The range indicates that countries have a different starting point and thus difference in the potential societal costs and benefits.

Source: Copenhagen Economics evaluation based on interviews with market stakeholders and desk research.

1) RECHARGE. (2024). *Stuck: 35GW red tape backlog threat to Sweden’s offshore wind boom.* / 2) World Nuclear Association: *Nuclear Power in Sweden*

Instrument 2: A market-wide capacity remuneration mechanism (CRM) can yield high societal benefits

Scope of the instrument	A CRM ensures payments for capacity that is available for dispatch, when needed in the system. This increases the security of supply and flexibility, which can reduce price peaks for electricity. A CRM is typically set up in competitive auctions, often with criteria relating to for example CO₂ intensity of the asset. Contracts are often long-term but can vary between 1 and 15 years.¹ A market-wide CRM ensures that both <i>existing</i> and <i>new</i> capacity options can participate in the auction, as well as both supply capacity and demand-side flexibility can partake.⁵
Societal benefits: MEDIUM – HIGH	Electricity production: Market-wide CRM can ensure adequate levels of capacity, particular in times of seasonal imbalances that last for multiple days or weeks, or if certain centralised production sites are interrupted for longer periods. Contrary to, for example, strategic reserves, a CRM ensures an efficient use of available resources in the energy market and is more proactive in managing adequacy problems in long-term contracts.² A CRM also provides benefits for the <i>security of electricity supply</i>. Transmission: A CRM can increase the level of demand-side flexibility, which would lower the peak demand and thus lower the need for transmission capacity. One study finds that ambitious demand-side flexibility could result in transmission capacity savings of EUR 200 million combined for Finland and Sweden by 2050.³ Widespread demand side flexibility can provide total system cost savings of 1 percent in 2030 and 1.37 per cent in 2050. Final demand: For enabling demand-side electrification, a market-wide CRM can help <i>lower prices and price volatility</i> in the electricity market. This is also confirmed by our power market simulation of a CRM in Finland and Sweden.⁴
Societal costs: MEDIUM – HIGH	Electricity production: Potential problems arise if existing electricity producing asset “shifts” too much toward a CRM instead of operating in the energy-only market. The design of a CRM needs to balance this. The lower electricity prices and volatility may also lower the profitability for flexible electricity supply that benefits from price variation, such as batteries, but these can take part in the CRM auctions.⁶ Government or electricity consumers: One estimate for market-wide CRM cost for Finland is estimated to be roughly EUR 5-10 per MWh (EUR 500-1,000 million per year) considering the total production capacity in Finland of 15 GW and an ambitious reliability target.⁷ These costs are either paid by the government or the consumers through tariffs. Given the larger share of hydro power in Sweden, the costs are likely to be lower per MWh for a similar reliability target, but unevenly distributed between the Swedish bidding zones due to different capacity needs in the different price zones.



Note: The figure is an illustration of what we expect the societal costs and benefits are. The range indicates that countries have a different starting point and thus difference in the potential societal costs and benefits.

Source: Copenhagen Economics evaluation based on interviews with market stakeholders and desk research.

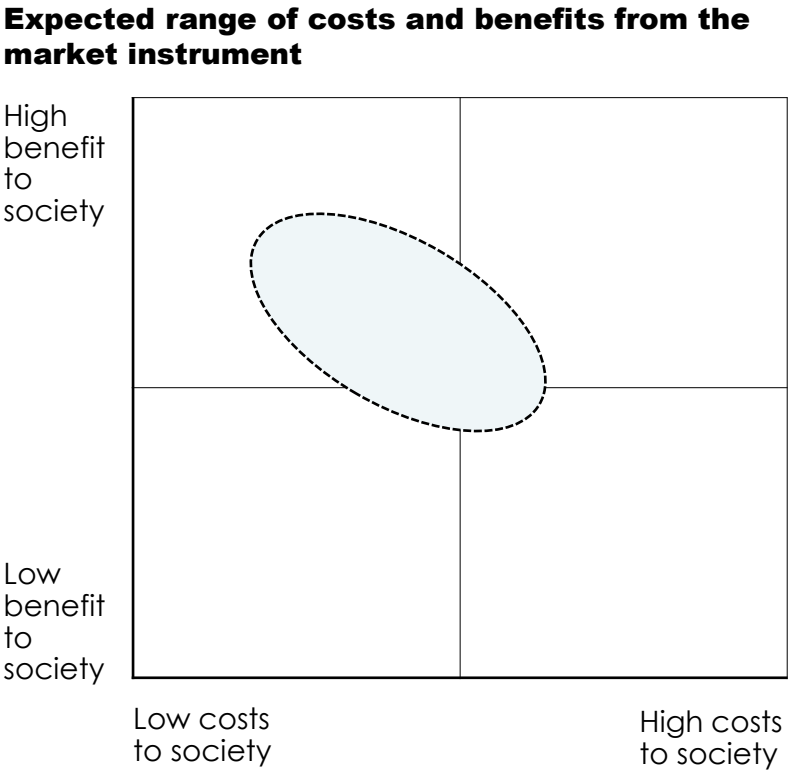
1) AFRY (2024), *How firm and flexible capacity supports Finland to become a green superpower* 2) Svenska Kraftnät (2023), *A future capacity mechanism to ensure resource adequacy in the electricity market.* / 3) EA Energianalyse (2023), *Value of demand flexibility* 4) We find lower prices and price variance in both Finland and Sweden from both supply-side and demand-side CRMs. In general, the impact of CRMs is larger in Finland than in Sweden / 5) In our interviews, some of the interviewees mentioned that their industry could offer demand-side flexibility. / 6) Svenska Kraftnät (2023), *A future capacity mechanism to ensure resource adequacy in the electricity market.* / 7) AFRY (2024), *A future capacity mechanism to ensure resource adequacy in the electricity market.*

Copenhagen Economics

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Instrument 3: Non-fossil flexibility support scheme (NFFSS) is a type of CRM but with certain restrictions

Scope of the instrument	A non-fossil flexibility support scheme (NFFSS) is a special type of CRM that only covers new and CO₂-neutral capacity and demand flexibility.¹ This could be (new) batteries, biogas or green hydrogen peakers, hydropower, nuclear power, and demand-side flexibility. NFFSS can also supplement a market-wide CRM.² The recent update of the EU electricity market design regulation³ states that "... Member States should be able to apply non-fossil flexibility support schemes consisting of payments for the available capacity of non-fossil flexibility. Furthermore, Member States that already apply a capacity mechanism should consider to promote the participation of non-fossil flexibility such as demand response and energy storage by redesigning criteria or features ... Member States that already apply a capacity mechanism should also be able to apply non-fossil flexibility support schemes" and that "Non-fossil flexibility ... shall: be limited to new investment in non-fossil flexibility resources such as demand side response and energy storage"
Societal benefits: MEDIUM - HIGH	The societal benefits are similar to the ones for market-wide CRM. However, there is a limited scope for who can participate in the auctions, so the net societal benefits are also expected to be lower.
Societal costs: LOW - MEDIUM	Electricity production: There is a risk that new non-fossil CRM assets will push out existing assets operating in the energy-only market. These existing assets cannot participate in the auction and cannot be subsidised under the CRM for availability of capacity. The overall societal costs of a non-fossil flexibility system is likely lower than the cost of a market-wide CRM due to a smaller scope (i.e., exiting capacity cannot participate in the CRM). The cost per MW capacity is, however, likely to be higher because there are fewer participants eligible in the CRM auctions, pushing up the auction clearing price.



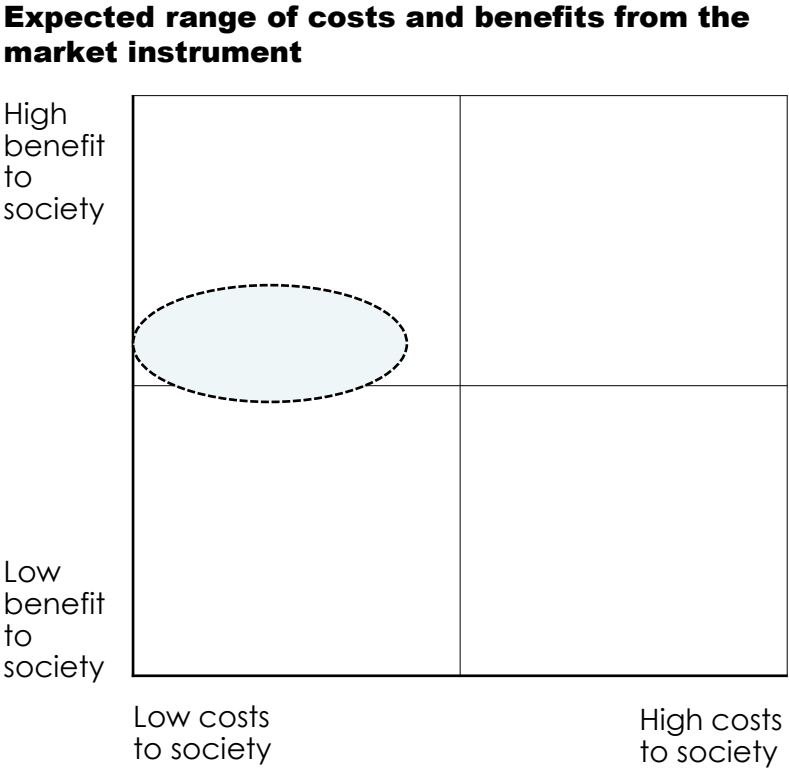
Note: The figure is an illustration of what we expect the societal costs and benefits are. The range indicates that countries have a different starting point and thus difference in the potential societal costs and benefits.

Source: Copenhagen Economics evaluation based on interviews with market stakeholders and desk research.

1) European Commission (2023), Commission welcomes deal on electricity market reform
2) European Commission (2023), Commission approves €1.3 billion French State aid scheme to support non-fossil technologies to ensure electricity supply matches demand
3) European Commission (2024), Regulation (EU) 2024/1747 of the European Parliament and of the council amending Regulations (EU) 2019/942 and (EU) 2019/943 as regards improving the Union's electricity market design

Instrument 4: Publicly-backed PPAs alleviate counterparty risks in long-term contracts but also have a societal cost

Scope of the instrument	The government insures an agreement for electricity purchases (PPAs) between an electricity supplier and one or more electricity consumers, <i>perhaps against an insurance fee</i>. In case of default by electricity users, the government pays the supplier for losses incurred in the market. As stated by the European Commission: “To address the current barriers such as the credit risks of buyers, the reform obliges Member States to ensure the availability of market-based guarantees for PPAs”.¹
Societal benefits: MEDIUM	Electricity production: Investments in new capacity are long-term investments with several years planning, permitting, and construction before electricity production and revenue streams commence. Due to this time horizon, it is difficult to lock in an electricity price that also has financial backing, particularly in new, unproven industries. There is a chicken and egg problem, as demand-side investors may not want to invest without PPAs, but at the same time it is too risky for supply-side investors to sign PPAs with demand-side investors in new, untested industries (e.g., renewable hydrogen) without financial backing. With publicly-backed PPAs, the government can lower risk for investors which would, in turn, lower the cost of capital for investors and incentivise investments. Final demand: With publicly-backed PPAs, new electricity demand has better possibilities to secure long-term contracts.
Societal costs: LOW – MEDIUM	Electricity production: Publicly-backed PPAs may distort the energy market by giving preferential treatment to certain projects/technologies over others. However, the instrument can be technology neutral in its design. Government: The expected government costs can be zero if the government operates as an insurer and receives an insurance premium, which is used in Norway and the UK.² If publicly-backed PPAs are implemented, it is paramount for the government to spread the risk across several PPAs and perhaps across different technologies. Societal costs: The total net costs for publicly-backed PPAs are not <i>necessarily</i> large. In principle, the potential payment from the government to the energy supplier gives a <i>net cost of zero</i>; one part of the value chain gains, and another has an equivalent cost.



Note: The figure is an illustration of what we expect the societal costs and benefits are. The range indicates that countries have a different starting point and thus difference in the potential societal costs and benefits.

Source: Copenhagen Economics evaluation based on interviews with market stakeholders and desk research.

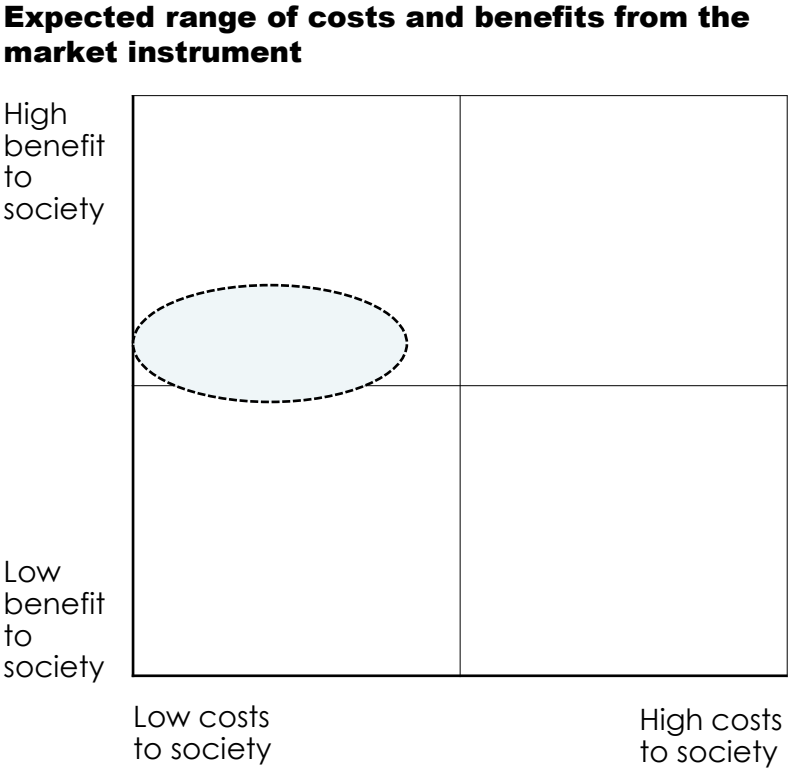
1) These schemes are typically market conform and need a Guarantee Notice. See European Commission, *Commission proposes reform of the EU electricity market design to boost renewables, better protect consumers and enhance industrial competitiveness* / 2) **Norway** has an Energy Purchase Guarantee scheme, which offers two different guarantees: i) a guarantee to the power seller, which safeguards against the buyer's failure to fulfil the agreement, ii) a guarantee to banks, which safeguards the repayment of loans that the buyer has taken out for the payment of the supply of power. The scheme is self-financing, as the guarantees are offered on commercial terms, financed with annual premiums. **The UK** has an “Offtaker of Last Resort scheme”, in which power producers can sell PPAs if they could not sell on market terms. The price of the PPAs is based on a market price index minus a discount. The PPAs are allocated through a competitive auction process. See Eksfin: *Power purchase guarantee* and OFGEM: *Offtaker of Last Resort (OLR)*.

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Instrument 5: Two-way Contract for Difference (CfD) auctions ensure a fixed price for new capacity

Scope of the instrument	A two-way CfD ensures a fixed price for produced electricity, for example for offshore wind or nuclear power. A CfD is typically awarded in competitive auctions where bidders provide their asset design and a strike price.¹ The government or electricity consumers pay the net cost between the strike price and the market price to the winners of these auctions.
Societal benefits: MEDIUM	Electricity production: Like publicly-backed PPAs: Investors in, for example, new nuclear or offshore wind face long time horizons and have difficulties securing certainty for future revenue against new demand without financial backing. Revenue backing through two-way CfD reduces the financial risk for developers, which encourages more investment in renewable energy projects through reduced cost of capital for projects – both for new supply under the CfD and for demand investments. Additionally, a two-way CfD provides benefits by returning excess profits when prices are high and encouraging new supply, which lowers electricity prices. Final demand: A two-way CfD increases the power supply and pushes down the overall cost of electricity which benefits electricity consumers but results in lower revenue to existing electricity production.
Societal costs: LOW – MEDIUM	Electricity production: CfDs may distort the energy market by giving preferential treatment to certain supply-side technologies over others. Government or consumers: Potential costs of the CfD are either paid by the government or electricity users. In case of price hikes, the additional revenue that is earned above the strike price in the market is channelled back to the electricity users. Societal costs: The net payment for a two-way CfD is paid by the government or electricity users to the supply-side capacity owner. This means that the <i>total net societal cost of this transaction is zero</i>.



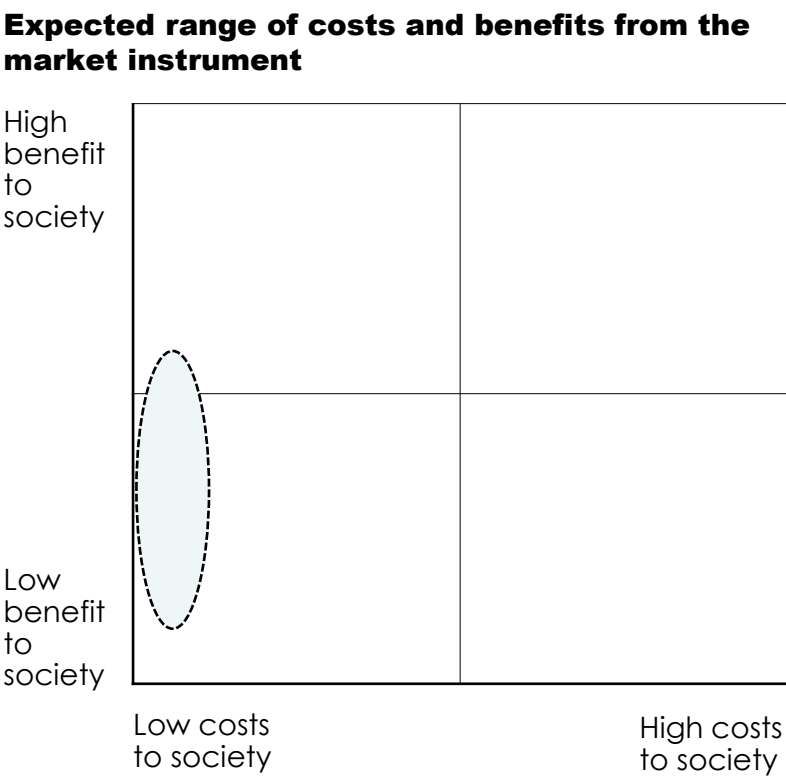
Note: The figure is an illustration of what we expect the societal costs and benefits are. The range indicates that countries have a different starting point and thus difference in the potential societal costs and benefits.

Source: Copenhagen Economics evaluation based on interviews with market stakeholders and desk research.

1) One example is the strike price of 44.07 ER/MWh in the UK offshore CfD round for 2022. Source: UK Gov (2022), *Contracts for Difference (CfD) Allocation Round 4: results*.

Instrument 6: Geographically differentiated tariffs incentivise optimal location of new demand in the grid at low cost

Scope of the instrument	Geographically differentiated tariffs¹ ensure that the prices paid by industrial users of electricity reflect the actual cost of delivering electricity to their location. The aim of differentiated tariffs is to encourage more efficient use of the grid by signalling the true costs associated with a grid connection for a specific place in the grid. Grid costs differ due to differences in grid losses, bottlenecks, and connection costs in different locations. Fingrid has discussed implementing a type of geographically differentiated tariffs, called <i>connection capacity tariff</i>.²
Societal benefits: LOW – MEDIUM	Societal benefits: Findings from Denmark³ suggest that there is a socioeconomic benefit up to EUR 20 million annually in Denmark from geographically differentiated tariffs. This happens through: • New electricity customers receive a financial incentive to connect to locations within the collective electricity network where capacity is available. • Existing electricity customers are encouraged to adjust their electricity consumption pattern to more accurately reflect the costs they incur. • Shorter lead time to connect to the grid in areas with excess capacity. Similar benefits can be expected in Finland and Sweden, but the benefits are likely to be larger, given the higher electricity demand and longer distances of the grid, meaning that the actual costs pertaining to the grid may differ even more across Finland and Sweden than in Denmark.
Societal costs: LOW	Societal costs: There are limited net costs related to this instrument. However, there would be a distribution effect through the differentiation of tariffs meaning that some electricity consumers would pay more, and others less. Fingrid has recently proposed to introduce differentiated tariffs to help balance supply and demand, reduce grid investment needs, and help Finland remain a single bidding zone.⁴ This would hit areas with current grid constraints in Finland, whereas areas with excess grid capacity would pay lower tariffs. This effect will likely diminish over time as capacity bottlenecks will be levelled out.



Note: The figure is an illustration of what we expect the societal costs and benefits are. The range indicates that countries have a different starting point and thus difference in the potential societal costs and benefits.

Source: Copenhagen Economics evaluation based on interviews with market stakeholders and desk research.

1) This is not an instrument to differentiate in different price zones. Rather, the instrument can in some instances work as a substitute to price zones. / 2) Fingrid (2024): Muutosehdotuksia kantaverkkomaksujen Rakenteeseen. / 3) Energistyrelsen (2021): Analyse af geografisk differentierede forbrugstariffer og direkte linjer. / 4) Fingrid (2024): Fingrid proposes reforms to the structure of grid service fees.

RECOMMENDATIONS FOR AN OPTIMAL MARKET DESIGN

Chapter 3

Finland and Sweden should consider implementing market instruments that deliver the highest expected benefits relative to their costs

In the previous chapters, we found large economic benefits from electrification investments in Finland and Sweden by going beyond a delayed electrification scenario to an ambitious decarbonisation scenario or an electricity doubling scenario.

For these benefits to materialise, the uncertainties for demand-side investors must be lowered. We identified six instruments that can be effective at reducing risk for demand-side and supply-side investors.

In this chapter, we go a step further and recommend a 'package of instruments' for Finland and Sweden respectively¹, based on our findings in the two previous chapters. Some of the instruments are complimentary and can be implemented simultaneously, whereas other instruments can be used and adopted interchangeably depending on the exact design and need of the market.

The marginal societal benefits from implementing the instruments are uncertain. Large-scale electrification investments may be subject to international competition, and investors may deem other locations more attractive, even if Finland and Sweden succeed in developing strong and supportive market designs for demand-side electrification investments.

Therefore, implementing the recommended instruments in Finland and Sweden should be interpreted as increasing the *likelihood* of attracting these investments to Finland and/or Sweden, but the instruments are not *sufficient* in making investments materialise. Other factors are at play as well – some well beyond the control of the two countries.

Expected benefits and costs of the instruments are not constant with increasing implementation

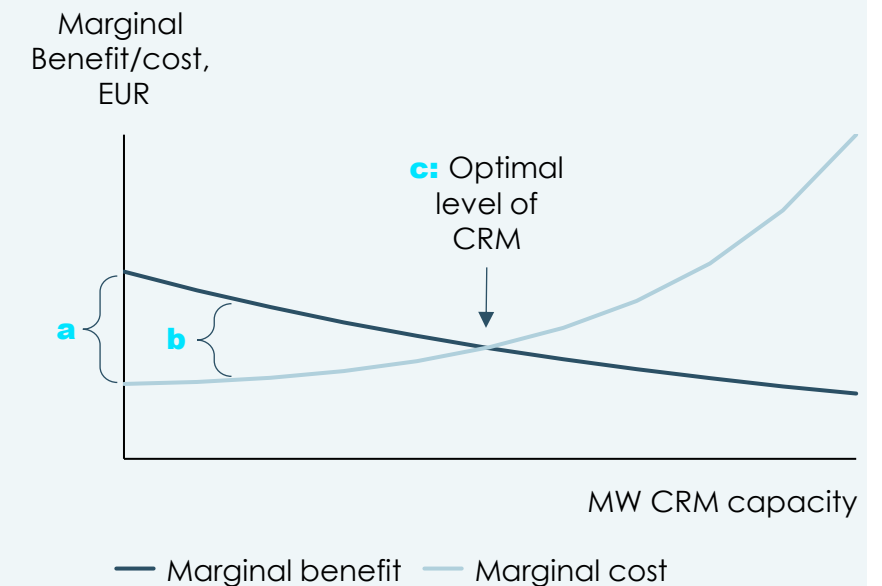
In our recommendation, we do not explicitly state how these instruments should be implemented, nor how the exact scope or design should be in Finland or Sweden. This will come down to specific impact assessments of the instruments, something which is normally treated with great care and scrutiny by TSOs and National Energy Agencies.² The instruments that we have identified are associated with societal benefits, but also societal costs.

In the example to the right, we illustrate this trade-off with an unspecified type of CRM that, starting from 0 MW CRM capacity, has a higher marginal societal benefit than its societal marginal cost, see **a** in figure.

The marginal societal benefits are expected to decrease with increasing MW capacity added to the system, whereas the marginal costs of CRM are expected to increase, lowering the net benefit of additional capacity, see **b** in figure. The optimal level of the CRM is when the marginal costs equal marginal benefits, see **c** in figure.

In practice, it is difficult to find such specific optimal levels, so instead other metrics can be used, for example 'how much CRM capacity is needed to lower the risk of blackouts by x per cent?'.

Conceptual illustration of marginal benefit and costs for a capacity remuneration mechanism



1) We consider the country-specific factors, such as geographical location, political landscape, and current supply mix of electricity. / 2) A more granular implementation plan and design of the various instruments in a Finnish and Swedish specific context is beyond the scope of report.

A market-wide CRM and publicly-backed PPAs/CfDs are likely to deliver the best outcome for Finland

Finland would benefit from implementing a market-wide CRM (2), publicly-backed PPAs (4) or two-way CfDs (5), and geographically differentiated tariffs (6).

Mitigating capacity adequacy risks: Future capacity adequacy is a challenge in Finland, as stated by Fingrid¹. In our interviews, high electricity prices and price volatility were two main concerns by demand-side investors – which are both likely outcomes of capacity inadequacy.

Due to Finland's geographical location on the edge of Europe, and Finnish imports of energy from Russia coming to a halt, Finland has fewer options in terms of interconnections and therefore needs other solutions to ensure capacity adequacy at all times.

A form of capacity mechanism can help ensure sufficient capacity in the system, even with increased electricity demand and with a higher share of variable, intermittent generation, as also stated by Fingrid.¹

We find that a **market-wide CRM is the optimal solution** for Finland, as Finland needs both existing and potential new entrants to ensure capacity, as well as demand-side flexibility to participate in the CRM auctions.² The reason why CRM is preferred over NFFSS is that a NFFSS comes with a risk of pushing out existing electricity producing assets, see the next page. Also, by including more potential bidders for the CRM auction, the clearing price would likely be lower per MW capacity.

A market-wide CRM will increase the reliability of the system, at a cost – but also with much more certainty for demand-side investors with more stable prices and a lower electricity price in the electricity market. The additional cost of the CRM can be paid by the

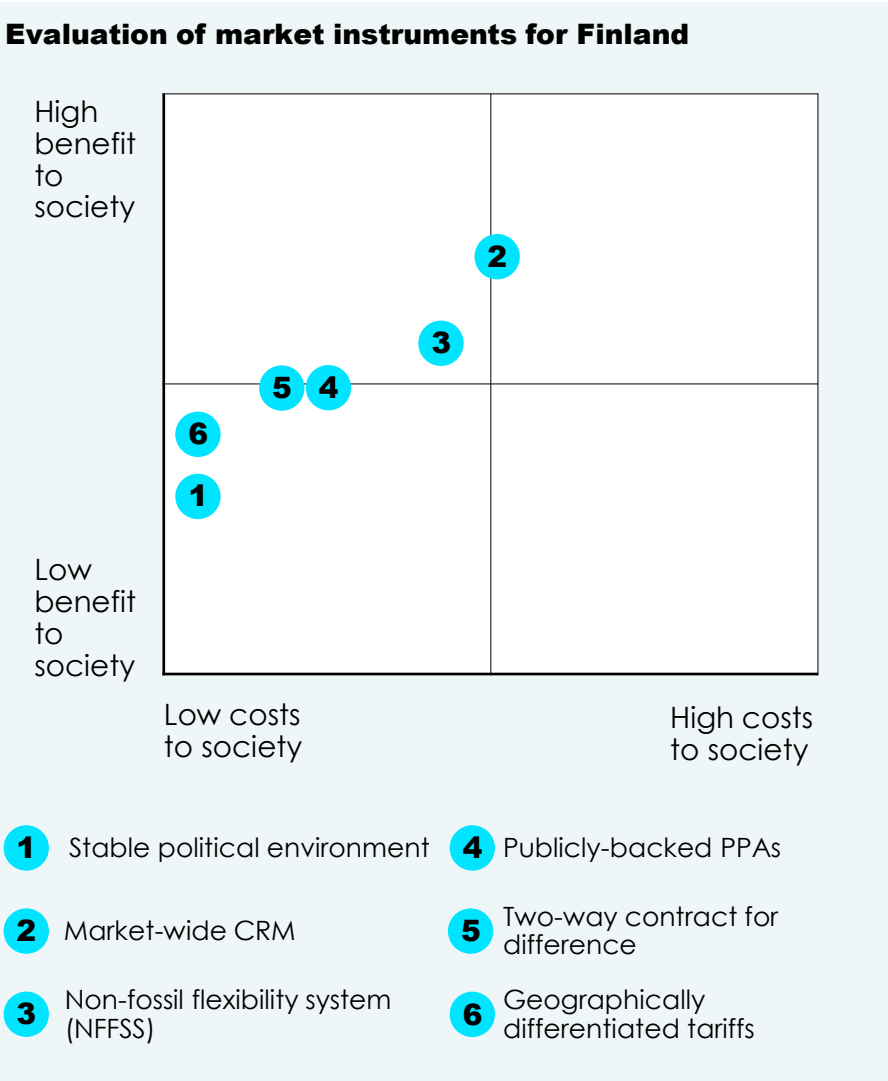
government or by electricity consumers (through tariffs). Ideally, the CRM should be planned/ordinated with similar systems in neighbouring counties (for example in Sweden, see page 35).³

Mitigating price and counterparty risks: Long investment time horizons, unproven demand-side electrification investments with limited financial backing, and potential cannibalisation of capture prices, all point to a need for an instrument that increases long-term revenue certainty and supply security for customers.

Publicly-backed PPAs and two-way CfDs are both strong instruments to ensure this. Publicly-backed PPAs may have slightly lower societal costs, because these are easier to use across multiple supply-side technologies and do not require the centralised auction setup. PPAs are by nature more bespoke over-the-counter products.⁴ An argument for CfDs is that they have already been used with success in several countries without interfering with the energy-only market,⁵ and would also be a good solution for increasing a technology-specific capacity in Finland, e.g., nuclear. Hence, both options are relevant.

Mitigating other risks: Geographically differentiated tariffs would likely achieve some societal benefits in Finland at a low cost by optimising grid development and investments in demand and supply from an economical perspective. The socio-economic benefits in Denmark were found to be up to EUR 20 million per year, and Finland's electricity demand is roughly double that of Denmark, so the impact is expected to be higher.

Geographically differentiated tariffs could also lower issues with future grid bottlenecks in Finland.



1) AFRY (2024), *A future capacity mechanism to ensure resource adequacy in the electricity market* / 2) The CRM should be proportionate to the underlying adequacy problem such that the capacity is sufficient to meet demand. / 3) As a short-term solution to ensure capacity, Finland could implement short-term targeted NFFSS before a larger role out of market-wide CRM. / 4) Also, CfD's are not planned for Finland's offshore wind auctions. EnergyWatch (2023): *Finland to launch 7.5GW offshore wind auction* / 5) See also Heussaff, C. and G. Zachmann (2024) *The changing dynamics of European electricity markets and the supply-demand mismatch risk*

Deep dive: long-term or large-scale implementation of NFFSS may risk pushing out existing assets over time

For existing energy producing assets in an energy-only market, the captured electricity prices need to cover both the assets' marginal costs and their capital expenses (fixed costs), see **A** in **Figure 1**.

Subsidising only new capacity/flexibility through NFFSS gives an advantage for new assets that can cover (in part or in full) their capital expenses. Increased capacity and/or increased flexibility will on average decrease capture prices for existing assets, see **A** and **B** in **Figure 2**.

This could result in the following situations:

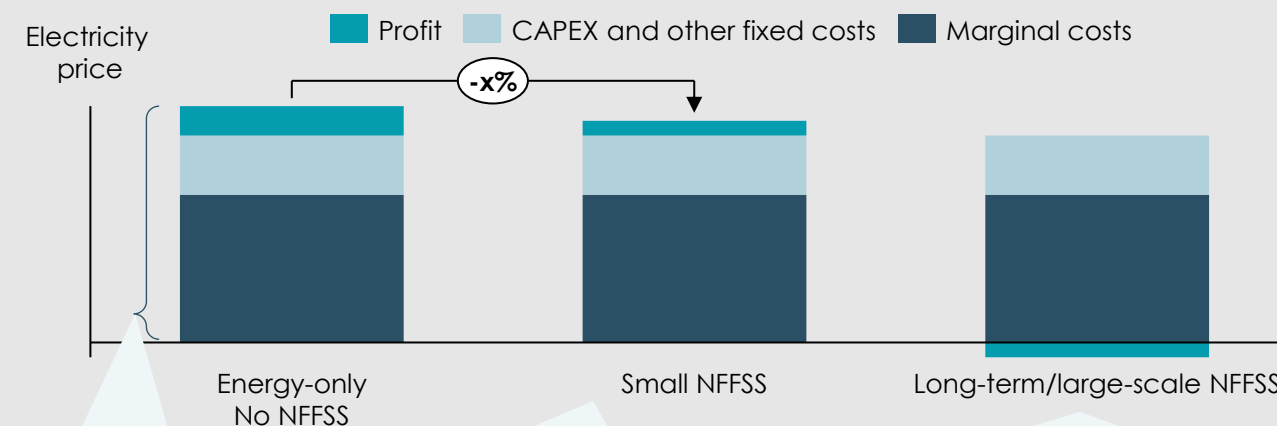
- An implementation of a small NFFSS would result in lowered captured prices for existing assets, which would lower their profits, see **B** in **Figure 1**.
- Over time, NFFSS can result in a price level that does not allow existing assets to reap profits sufficiently high to cover the fixed costs for the existing electricity producing assets, which would result in negative profits,

see **C** in **Figure 1**. This situation would likely discourage re-investments in the existing assets and over time drive could drive these assets out of production.¹

A market-wide CRM (including electricity producing assets, storage, and demand responses) would allow for existing assets to participate as a capacity in the CRM auction, which would lower the risk of driving existing electricity producing assets out of the market over time.

Figure 1: Decomposition of captured electricity prices for an existing electricity producing asset when introducing NFFSS

EUR per MWh



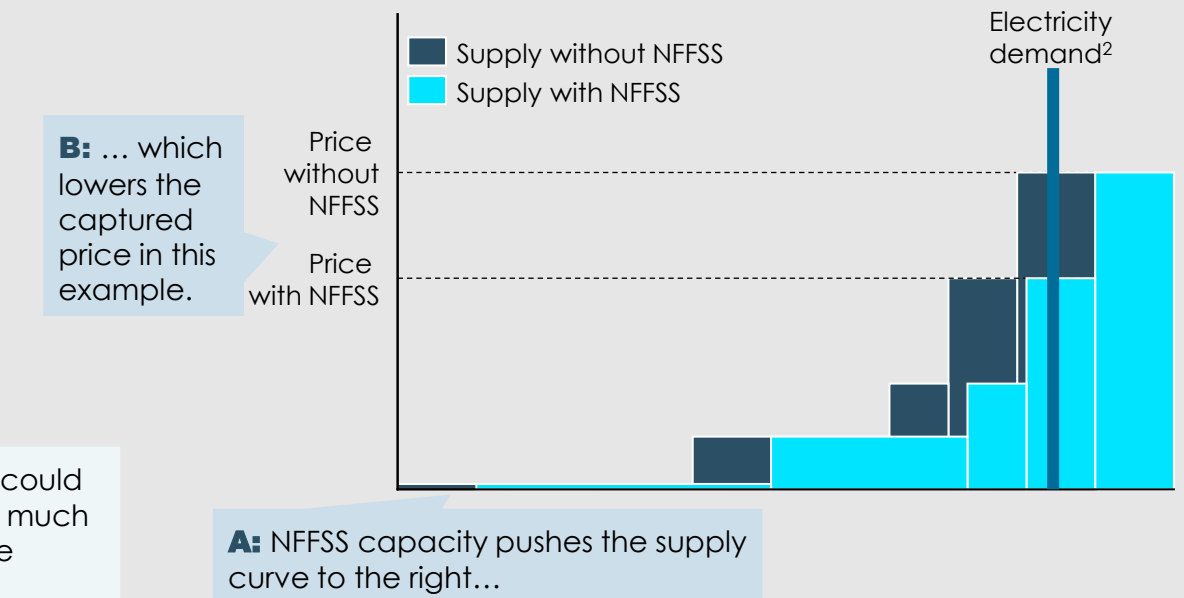
A: Captured prices need to cover marginal costs and fixed costs. What is left is profits.

B: The average electricity price declines with more flexibility, which lower the captured prices.

C: Long-term or large scale NFFSS could bring down the electricity price so much that it is no longer profitable for the existing asset to operate.

Figure 2: Introduction of (supply-side) NFFSS capacity in a merit order curve with supply and demand

EUR per MWh



1) In some cases, there may be a political objective to push out existing capacity, for example if the capacity is fossil-based. This is not the general case in Finland and Sweden, where most of the electricity generated comes from CO₂-neutral electricity production. /2) For illustrative simplicity, electricity demand is shown as inelastic. Demand-side NFFSS could also work as a shift in electricity demand to the left, which would have the same implication.

Note: The figures are simplifications for illustrative purposes. We do not consider specific technologies in these illustrations.

A stable political environment and a CRM instrument could deliver the best outcome for Sweden

Sweden would benefit from a more stable political environment (1) and from implementing a CRM instrument (e.g. 2/3), and publicly-backed PPAs (4) or two-way CfDs (5).

Mitigating institutional risks: In our interviews, some interviewees stressed that the political climate in Sweden is fragile and has been for some time. This has, for example, resulted in several changes to who pays for offshore wind grid connections¹, and political dismissal of wind projects that had already been approved.² Similarly, the political stance on nuclear has been unclear for several years.³

We conclude that a stable political environment would likely result in high societal benefit to society at a relatively low societal cost.

Mitigating capacity adequacy risks: Svenska Kraftnät has concluded that capacity inadequacy will be a future challenge in Sweden.⁴

We conclude that a CRM would be a useful instrument to implement in Sweden, but the potential upsides are lower than in Finland due to Sweden's proximity to other countries (Norway, Denmark, Germany, Poland, and the Baltic countries) and thus higher potentials for electricity balancing with other countries, and Sweden's larger share of hydro power in the electricity mix.

However, some form of CRM could still lower the risk of price hikes and lower price volatility in Sweden, which could enable demand-side electrification investments.

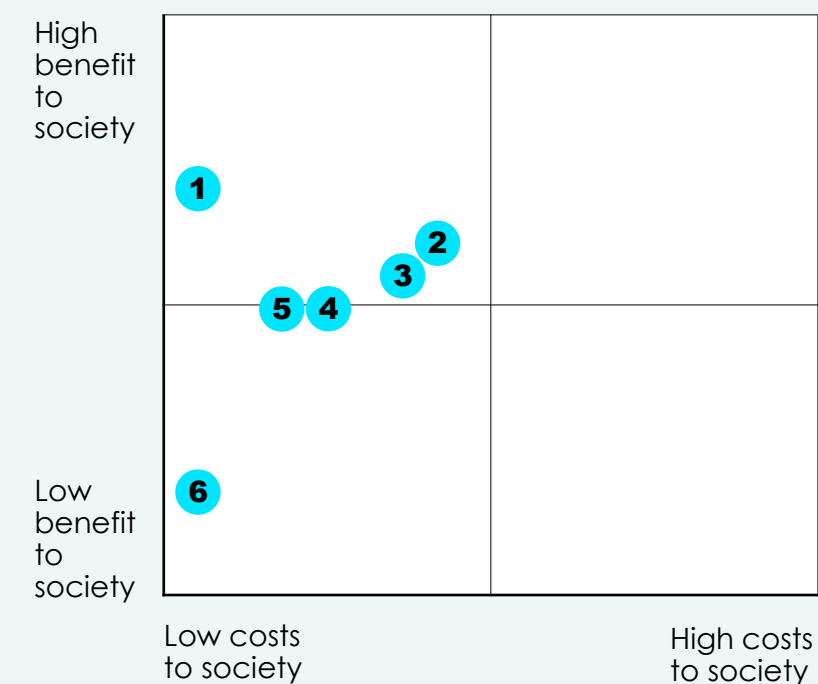
As in Finland, there is a risk that non-fossil flexibility systems may push out existing electricity producing assets, see previous slide.⁵

Mitigating counterparty risks: Like Finland, there may be a need for an instrument that increases long-term revenue certainty for supply-side investors. Publicly-backed PPAs and two-way CfDs are both strong instruments to ensure this revenue. This will also lower the capacity adequacy risks in Sweden – especially in an electricity doubling scenario.

We do not have reason to believe that the societal benefits or costs are different in Sweden relative to Finland, and the conclusion is thus the same that Sweden could consider implementing publicly-backed PPAs and/or CfDs to lower counterparty risks.

Other risks: Sweden already has differentiation in the grid costs based on the four price zones SE1-SE4, and thus lower extra benefit from more geographically differentiated grid tariffs.

Evaluation of market instruments for Sweden



- 1 Stable political environment
- 2 Market-wide CRM
- 3 Non-fossil flexibility system (NFFSS)
- 4 Publicly-backed PPAs
- 5 Two-way contract for difference
- 6 Geographically differentiated tariffs

1) RECHARGE. (2024). Stuck: 35GW red tape backlog threat to Sweden's offshore wind boom. / 2) EnergyWatch. (2023). Statkraft receives rejection for double-approved wind farm. / 3) World Nuclear Association: Nuclear Power in Sweden / 4) Svenska Kraftnät (2023), A future capacity mechanism to ensure resource adequacy in the electricity market / 5) Similarly, CfDs could help add needed capacity from for example nuclear and/or offshore wind.

APPENDICES

Appendix A: Output results from INTERSECT

Appendix B: Description of selected market instruments

Appendix C: Methodology description

APPENDIX A: OUTPUT RESULTS FROM INTERSECT

OUTPUTS IN THE THREE SCENARIOS FOR FINLAND AND SWEDEN, RESPECTIVELY.

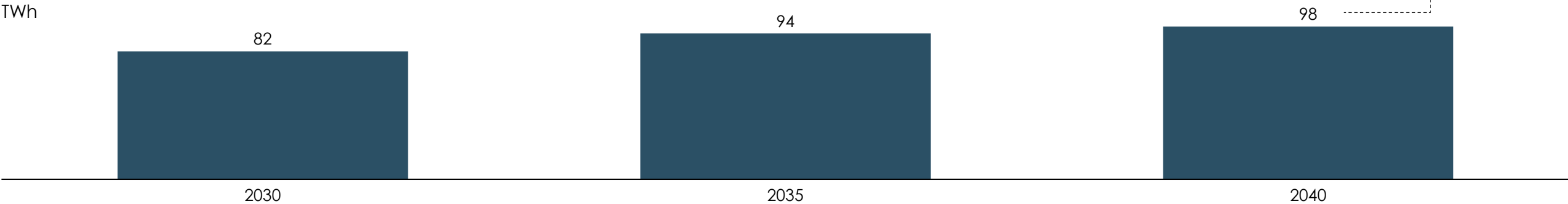
FOR EACH COUNTRY AND SCENARIO, THE FIGURES COVER:

- **ELECTRICITY DEMAND AND SUPPLY IN 2030, 2035, AND 2040**
- **JOB, GVA AND TAXES IN 2030, 2035, AND 2040**

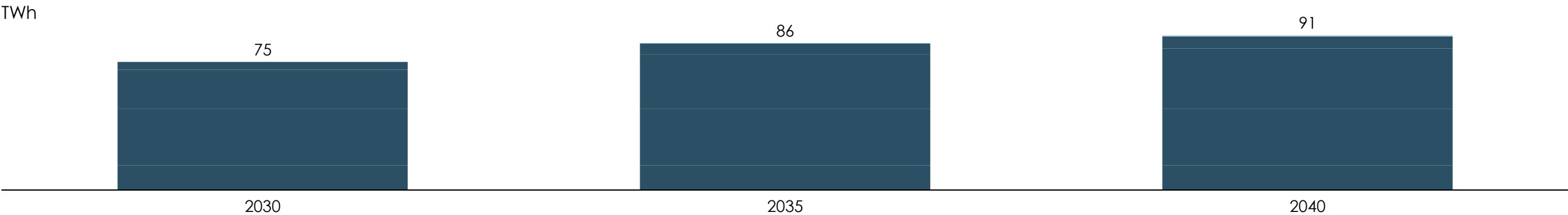
In the delayed electrification scenario, electricity demand increases to 98 TWh in *Finland* by 2040



Electricity demand in Finland – delayed electrification



Electricity supply in Finland – delayed electrification



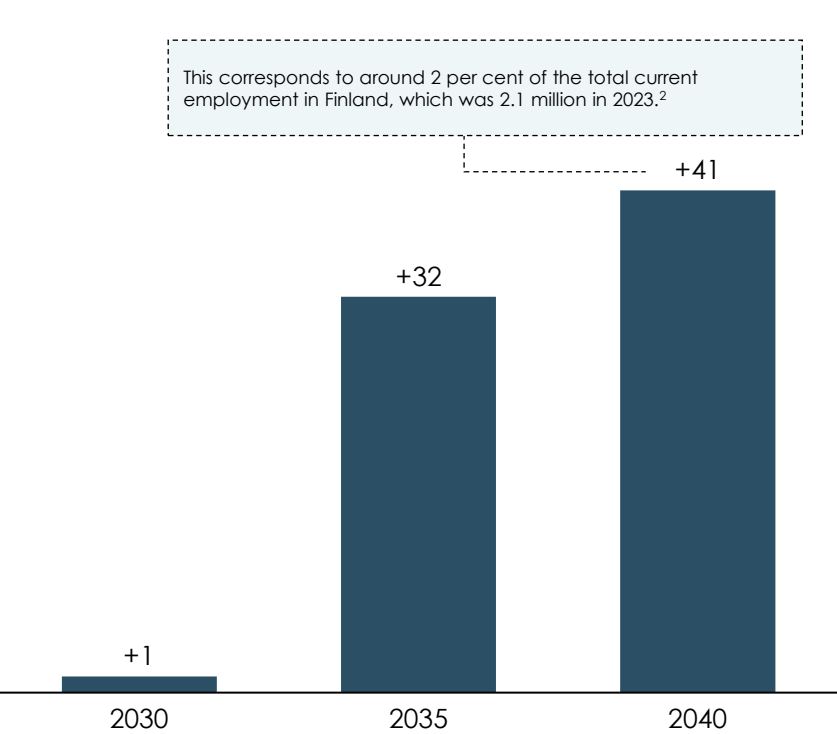
Source: Copenhagen Economics based on INTERSECT.

In the delayed electrification scenario, electrification can support an additional 41,000 jobs and EUR 9 billion in GVA in *Finland* in 2040



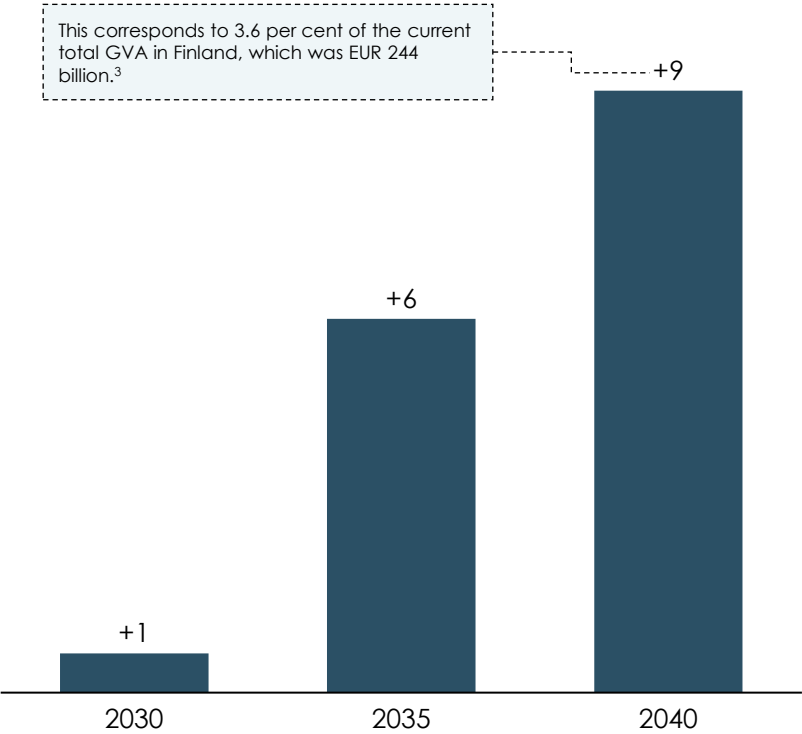
Total jobs from direct and indirect electrification – delayed electrification, relative to current levels¹

Thousand FTEs



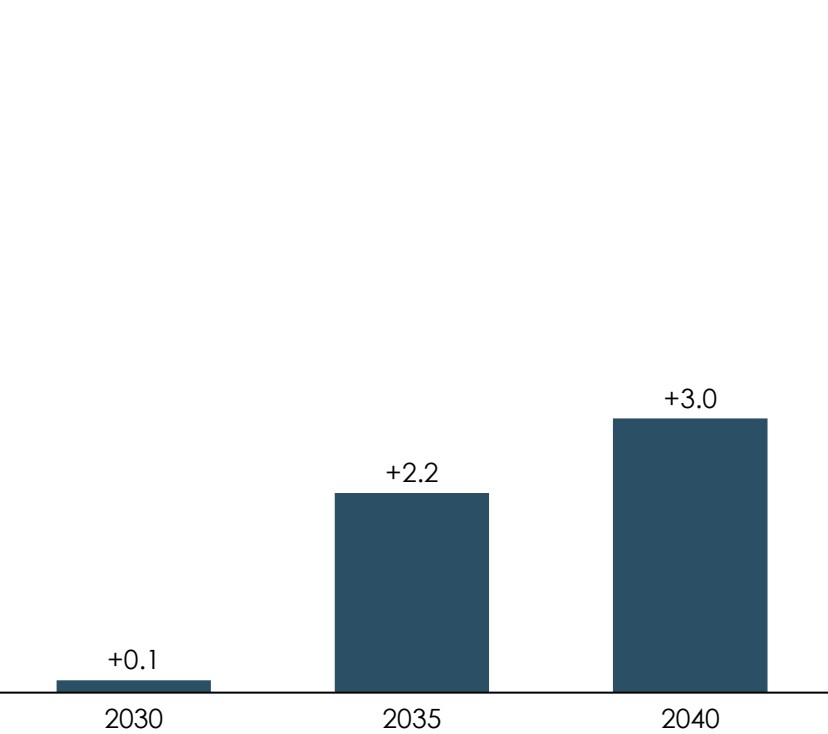
Total gross value added from direct and indirect electrification – delayed electrification, relative to current levels¹

EUR billion



Total taxes generated from direct and indirect electrification – delayed electrification, relative to current levels¹

EUR billion



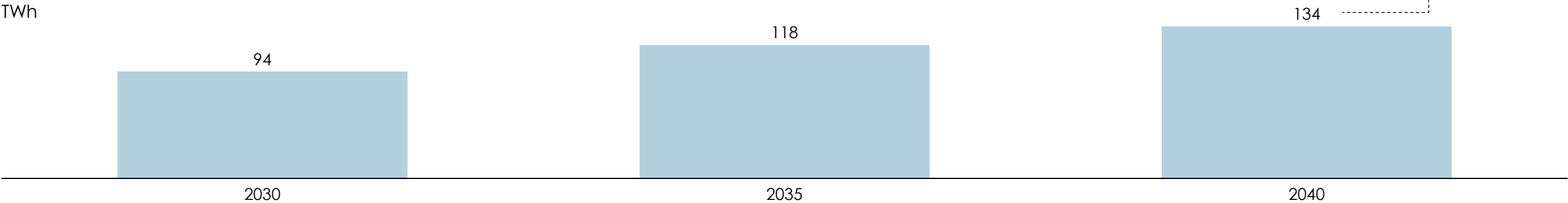
Note: Jobs include all direct jobs within electrifying industries and do not account for jobs previously relying on fossil fuels. Taxes include corporate taxes and income taxation, based on the remuneration of labour and capital from the value added, and the average tax rates in Finland. 2021-prices. Source: Copenhagen Economics based on INTERSECT.

1) Current levels are based on 2021 inputs.
2) Eurostat (2024), *Employment by sex, age, professional status and full-time/part-time*
3) Eurostat (2024), *Gross value added and income by A*10 industry breakdowns*

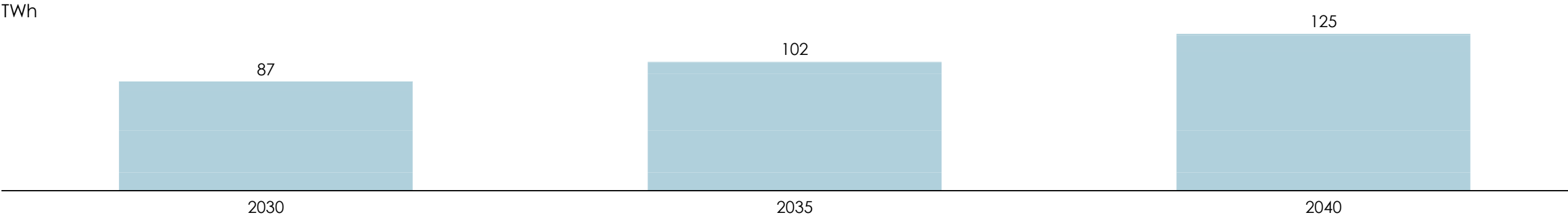
In the ambitious decarbonisation scenario, electricity demand increases to 134 TWh in *Finland* by 2040



Electricity demand in Finland – ambitious decarbonisation



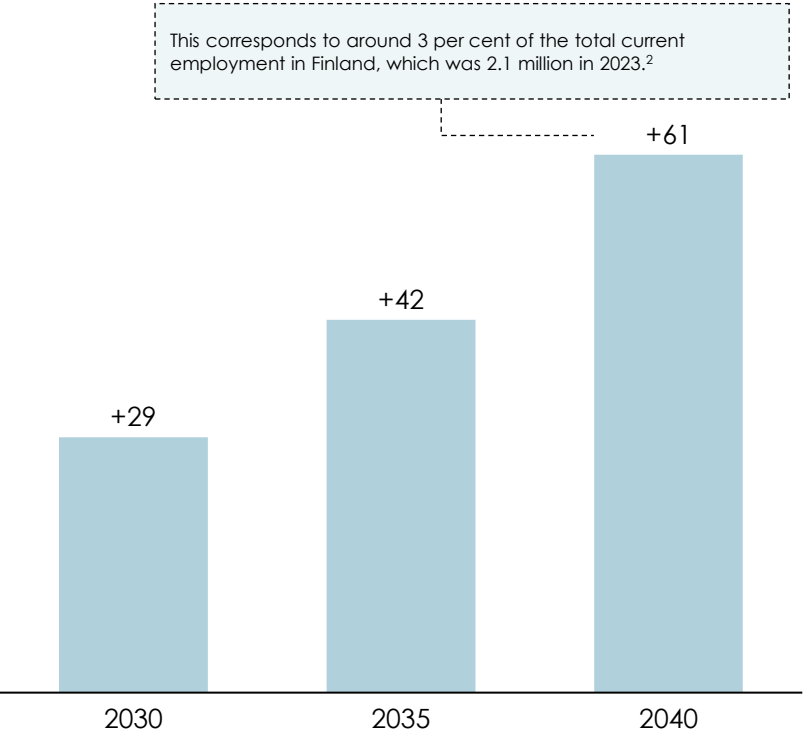
Electricity supply in Finland – ambitious decarbonisation



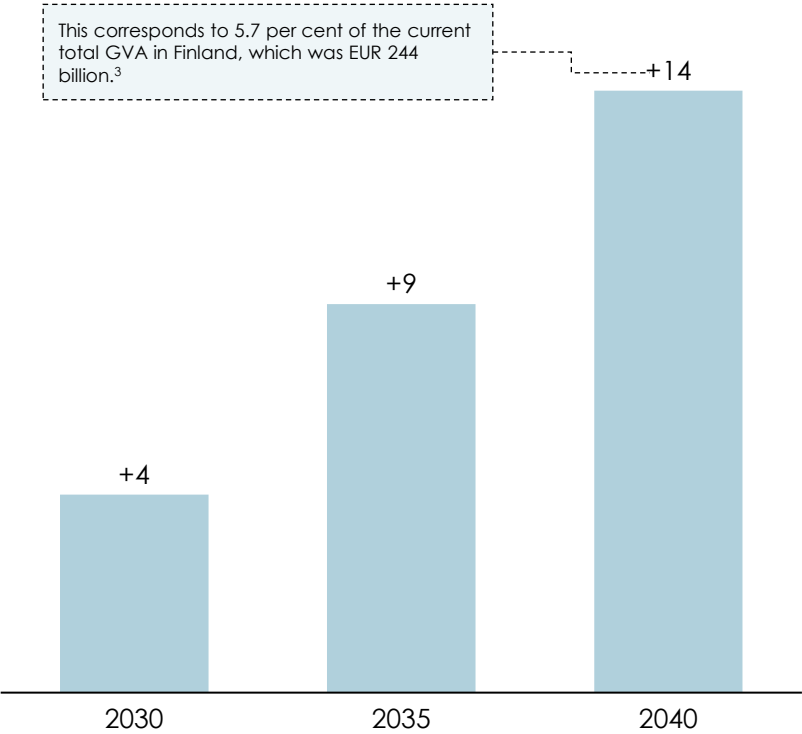
Source: Copenhagen Economics based on INTERSECT.

In the ambitious decarbonisation scenario, electrification can support an additional 61,000 jobs and EUR 14 billion in GVA in *Finland* in 2040

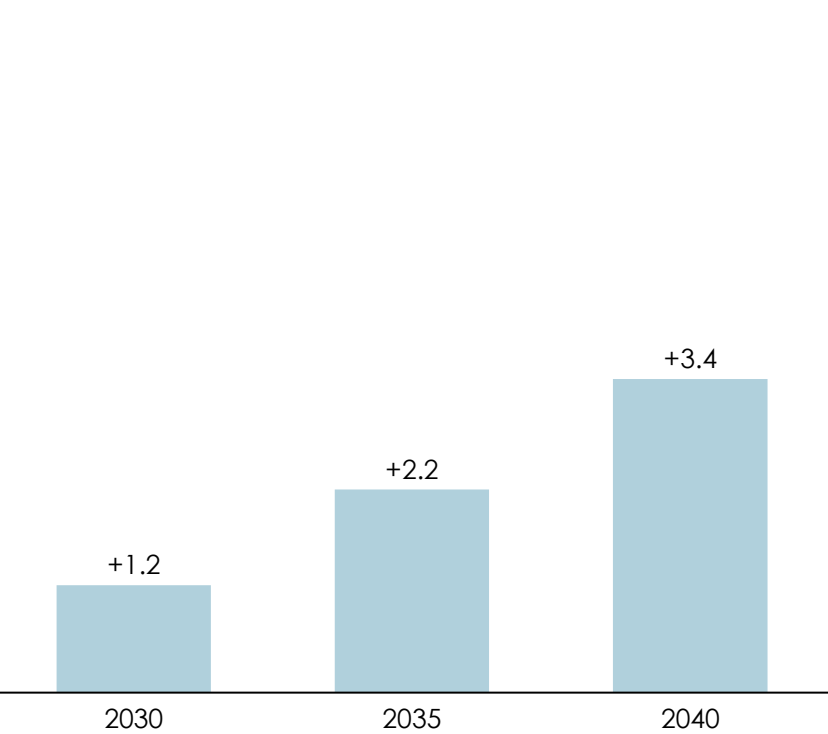
Total jobs from direct and indirect electrification – ambitious decarbonisation, relative to current levels¹
Thousand FTEs



Total gross value added from direct and indirect electrification – ambitious decarbonisation, relative to current levels¹
EUR billion



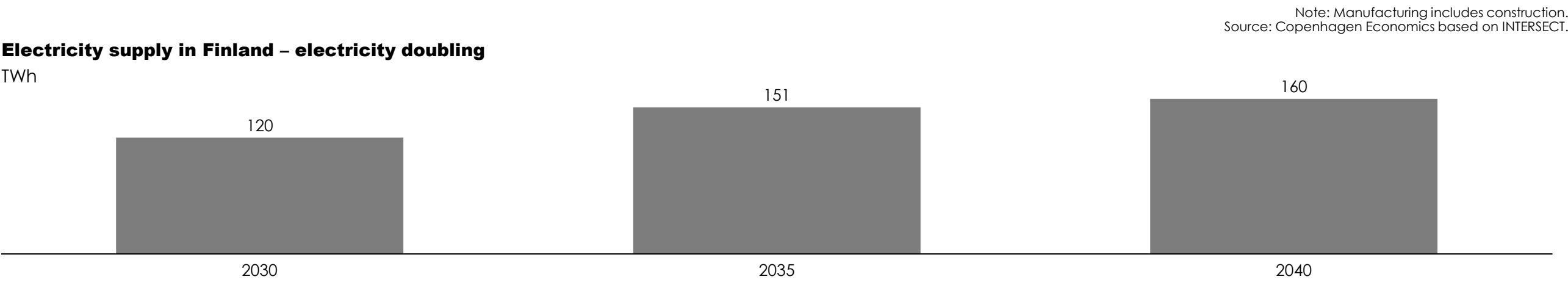
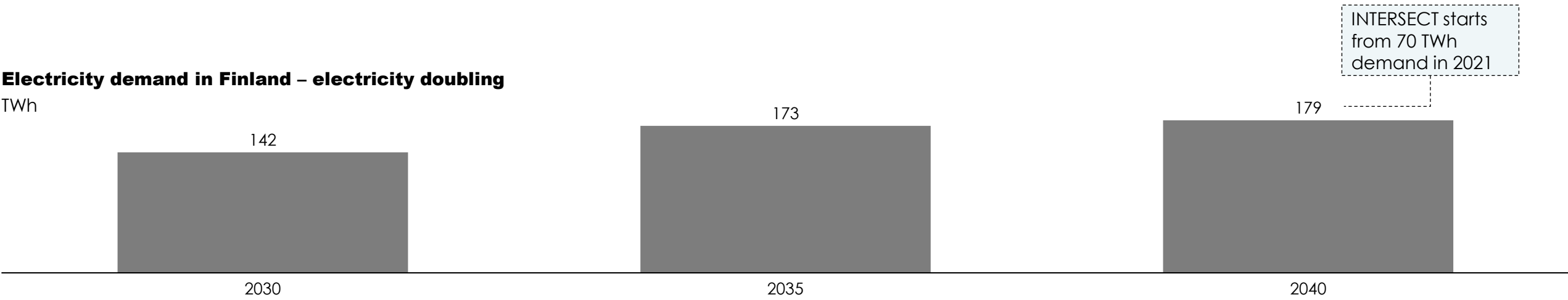
Total taxes generated from direct and indirect electrification – ambitious decarbonisation, relative to current levels¹
EUR billion



Note: Taxes include corporate taxes and income taxation, based on the remuneration of labour and capital from the value added, and the average tax rates in Finland. 2021-prices.
Source: Copenhagen Economics based on INTERSECT.

1) Current levels are based on 2021 inputs.
2) Eurostat (2024), *Employment by sex, age, professional status and full-time/part-time*
3) Eurostat (2024), *Gross value added and income by A*10 industry breakdowns*

In the electricity doubling scenario, electricity demand increases to 179 TWh in *Finland* by 2040



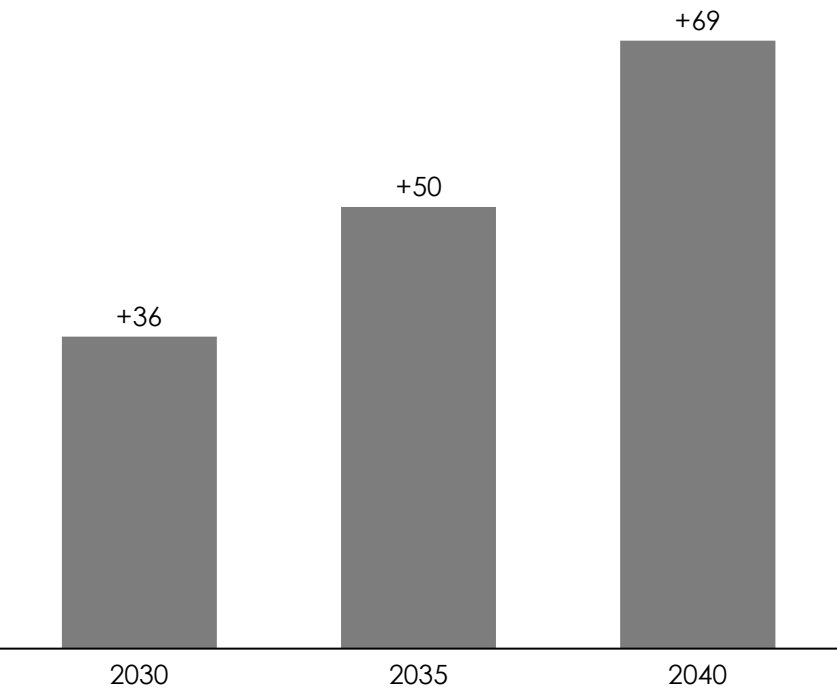
Source: Copenhagen Economics based on INTERSECT.

In the electricity doubling scenario, electrification can support an additional 69,000 jobs and EUR 17 billion in GVA in *Finland* in 2040



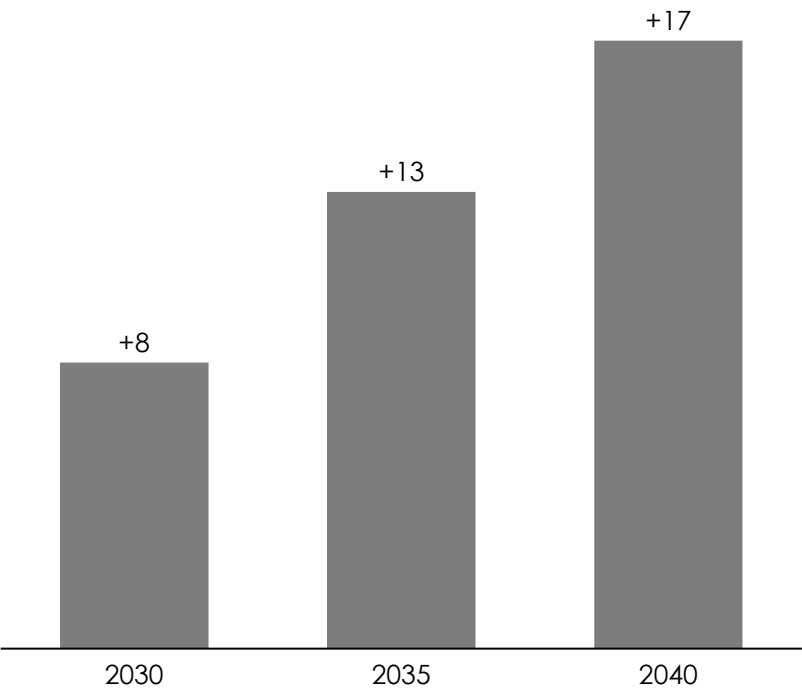
Total jobs from direct and indirect electrification – electricity doubling, relative to current levels¹

Thousand FTEs



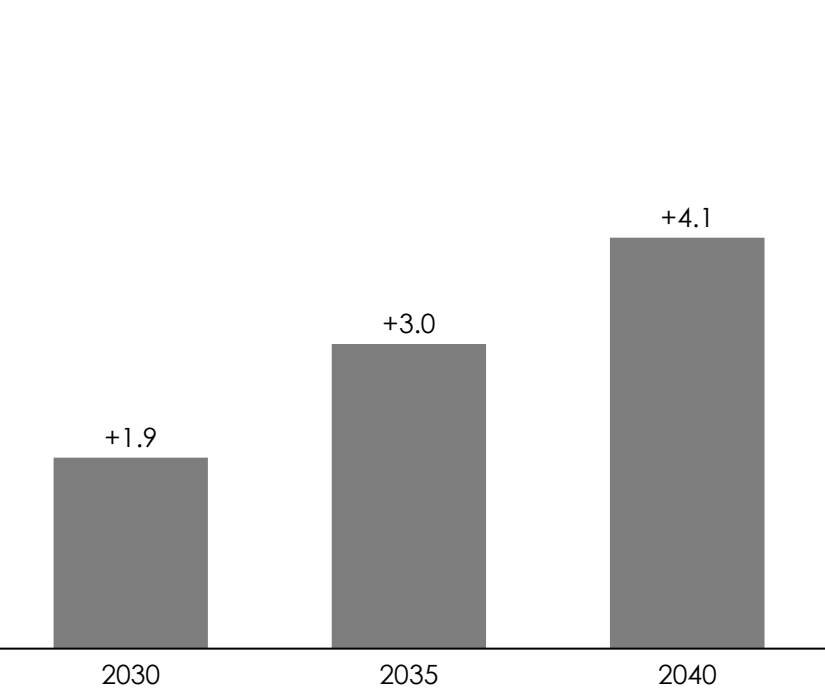
Total gross value added from direct and indirect electrification – electricity doubling, relative to current levels¹

EUR billion



Total taxes generated from direct and indirect electrification – electricity doubling, relative to current levels¹

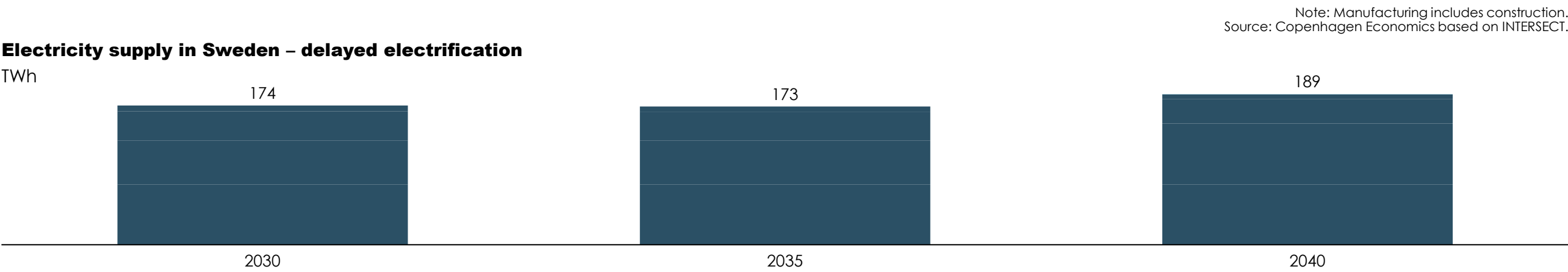
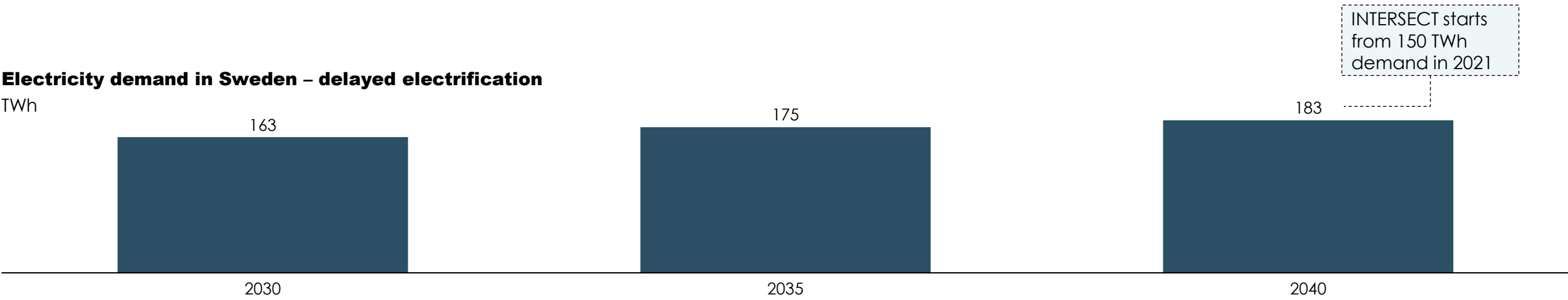
EUR billion



Note: Taxes include corporate taxes and income taxation, based on the remuneration of labour and capital from the value added, and the average tax rates in Finland. 2021-prices.
Source: Copenhagen Economics based on INTERSECT.

1) Current levels are based on 2021 inputs.

In the delayed electrification scenario, electricity demand increases to 183 TWh in *Sweden* by 2040



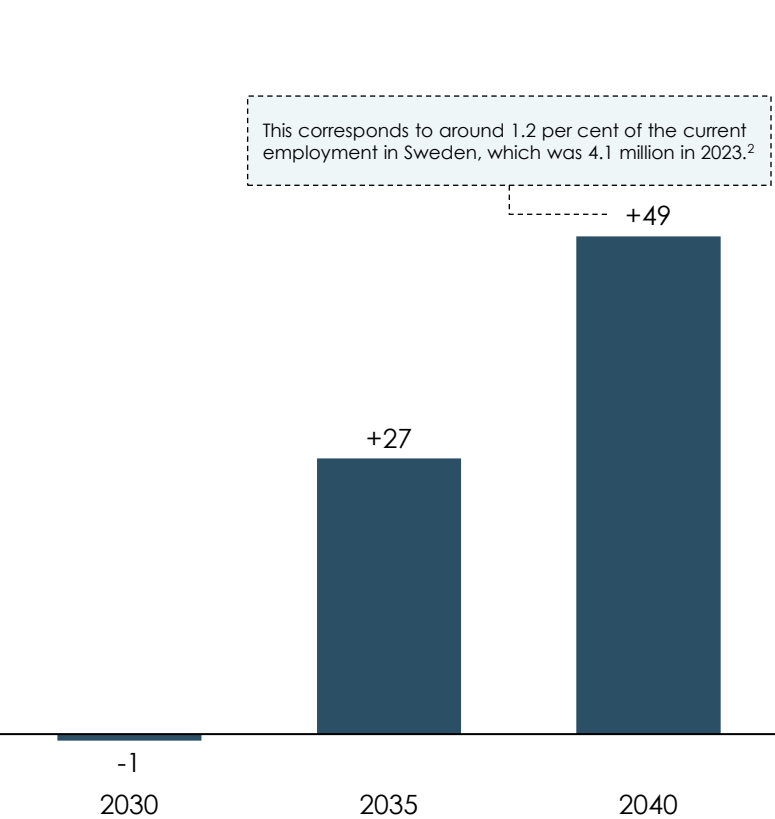
Source: Copenhagen Economics based on INTERSECT.

In the delayed electrification scenario, electrification can support an additional 49,000 jobs and EUR 14 billion in GVA in Sweden in 2040



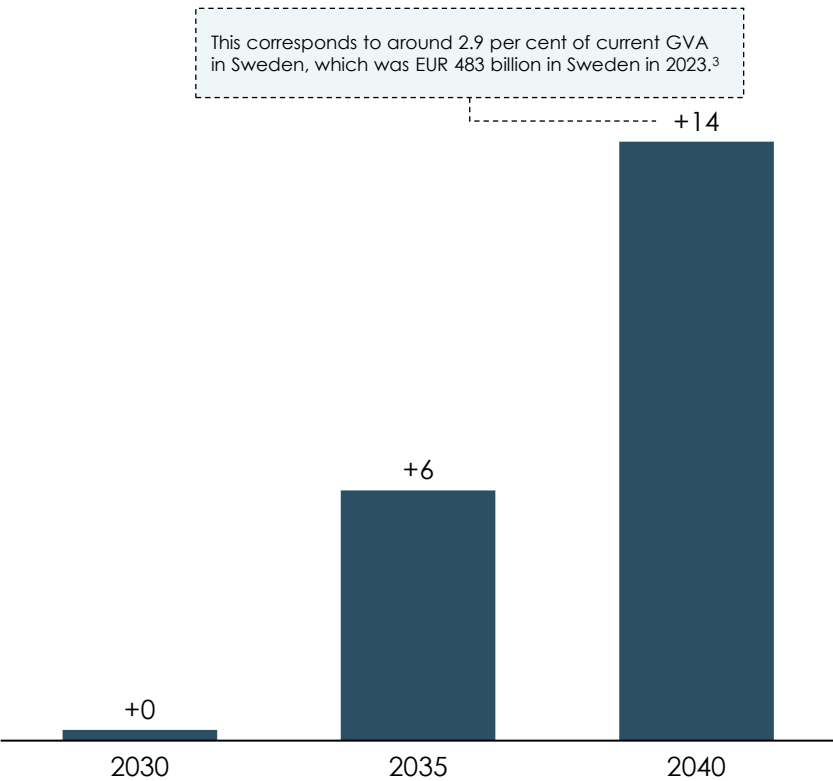
Total jobs from direct and indirect electrification – delayed electrification, relative to current levels¹

Thousand FTEs



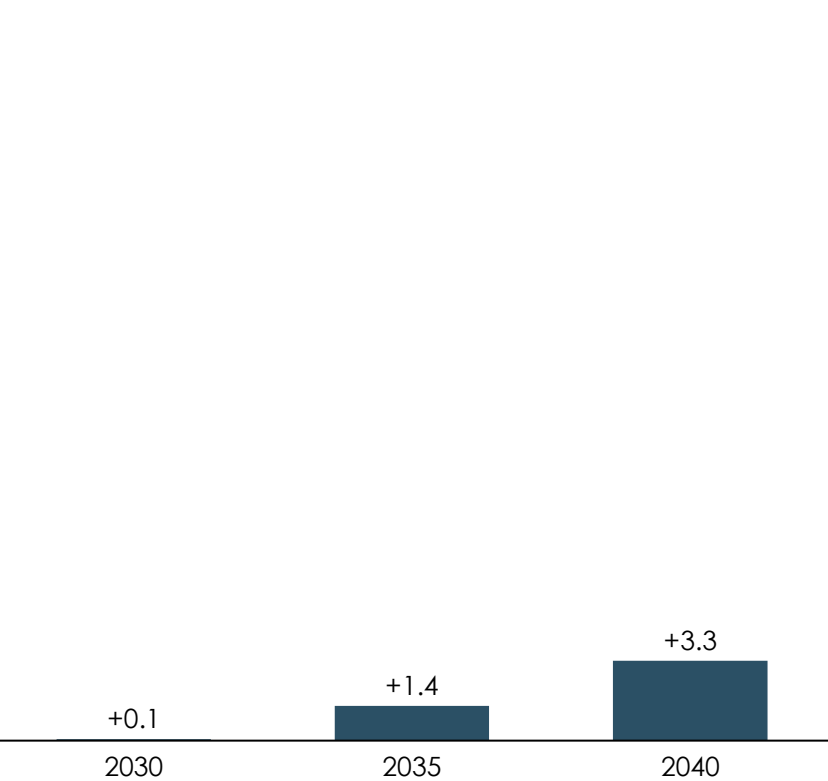
Total gross value added from direct and indirect electrification – delayed electrification, relative to current levels¹

EUR billion



Total taxes generated from direct and indirect electrification – delayed electrification, relative to current levels¹

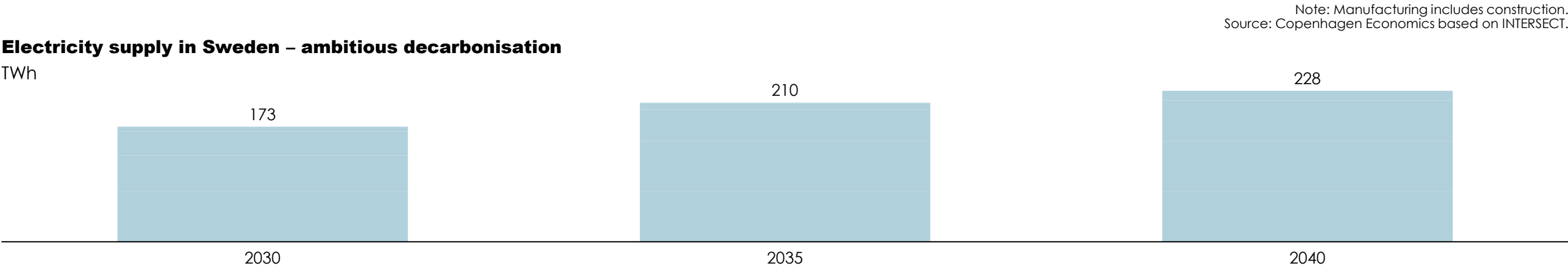
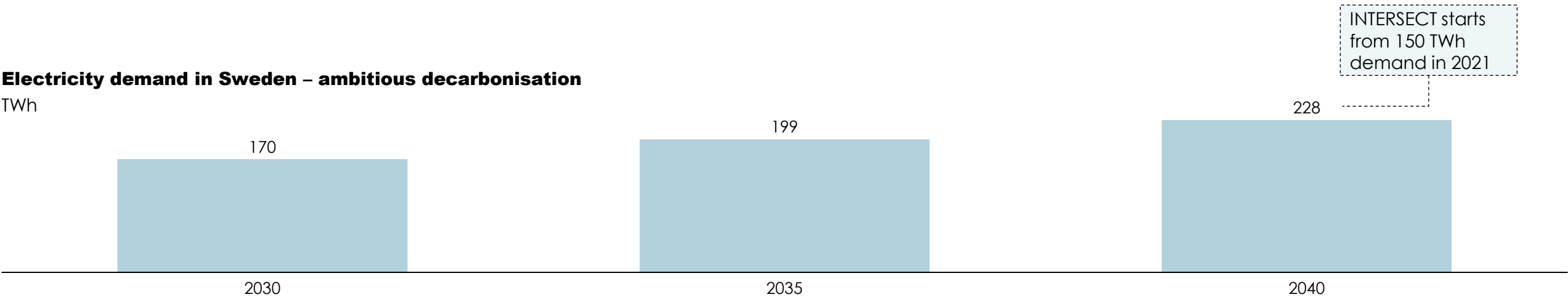
EUR billion



Note: Taxes include corporate taxes and income taxation, based on the remuneration of labour and capital from the value added, and the average tax rates in Sweden. 2021-prices.
Source: Copenhagen Economics based on INTERSECT.

1) Current levels are based on 2021 inputs.
2) Eurostat (2024), *Employment by sex, age, professional status and full-time/part-time*
3) Eurostat (2024), *Gross value added and income by A*10 industry breakdowns*

In the ambitious decarbonisation scenario, electricity demand increases to 228 TWh in *Sweden* by 2040



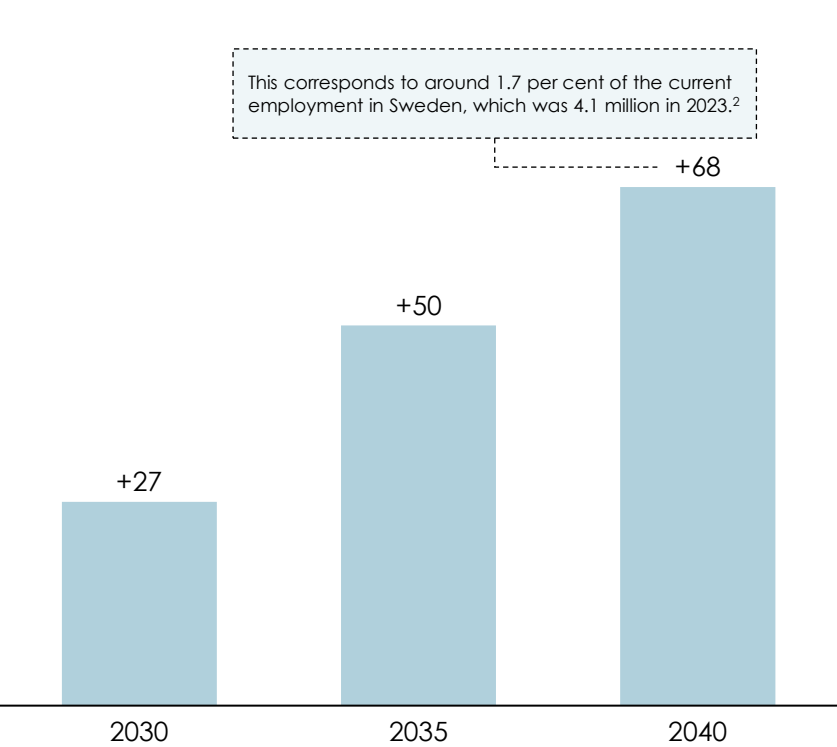
Source: Copenhagen Economics based on INTERSECT.

In the ambitious decarbonisation scenario, electrification can support an additional 68,000 jobs and EUR 18 billion in GVA in Sweden in 2040



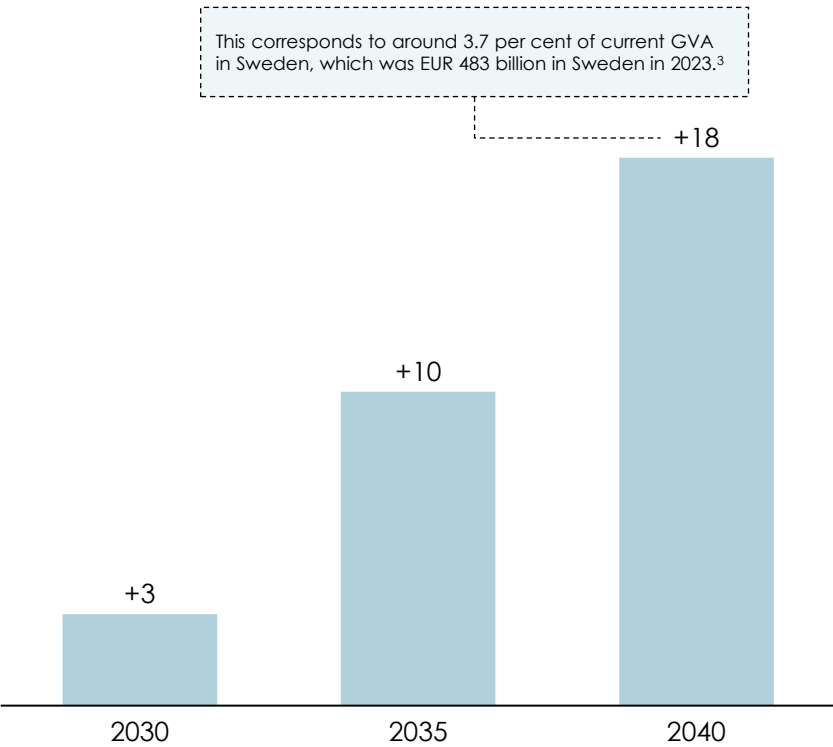
Total jobs from direct and indirect electrification – ambitious decarbonisation, relative to current levels¹

Thousand FTEs



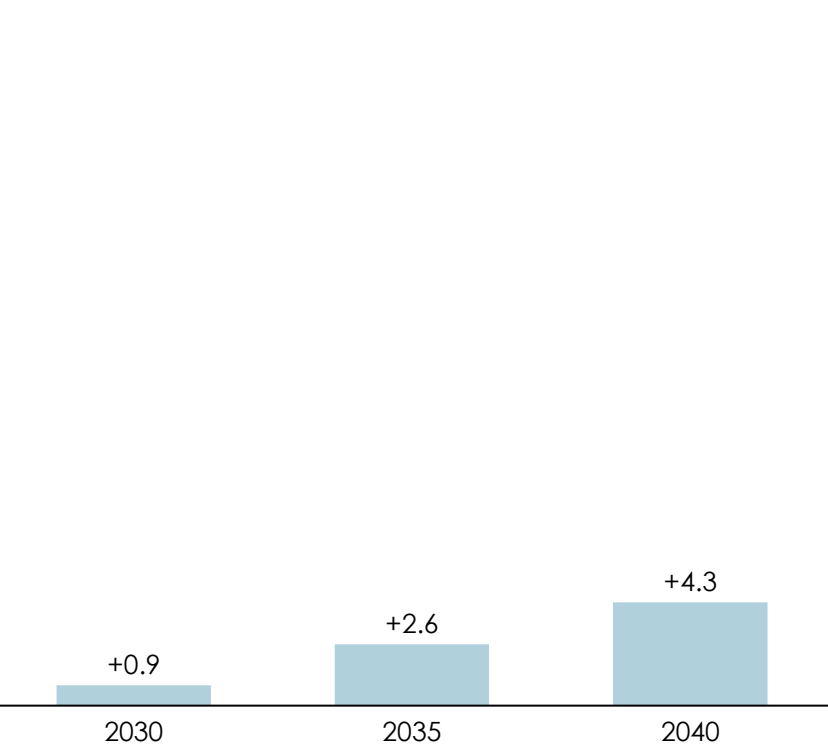
Total gross value added from direct and indirect electrification – ambitious decarbonisation, relative to current levels¹

EUR billion



Total taxes generated from direct and indirect electrification – ambitious decarbonisation, relative to current levels¹

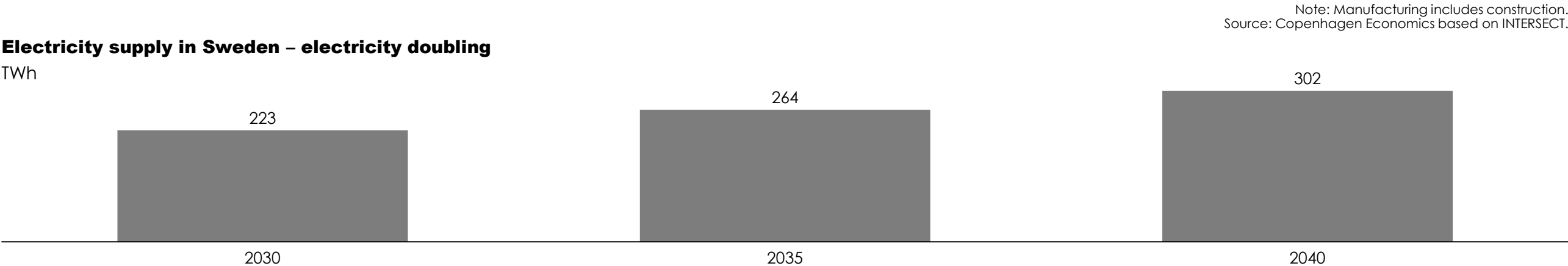
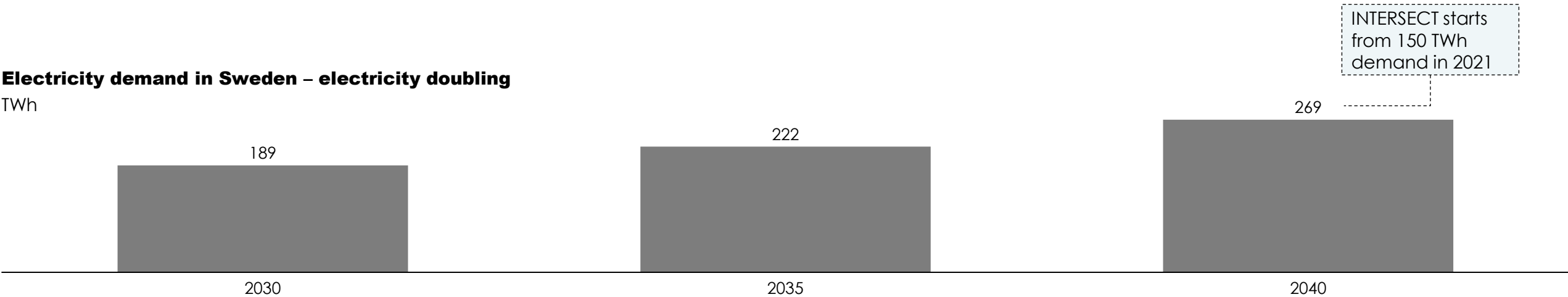
EUR billion



Note: Taxes include corporate taxes and income taxation, based on the remuneration of labour and capital from the value added, and the average tax rates in Sweden. 2021-prices.
Source: Copenhagen Economics based on INTERSECT.

1) Current levels are based on 2021 inputs.
2) Eurostat (2024), *Employment by sex, age, professional status and full-time/part-time*
3) Eurostat (2024), *Gross value added and income by A*10 industry breakdowns*

In the electricity doubling scenario, electricity demand increases to 269 TWh in *Sweden* by 2040



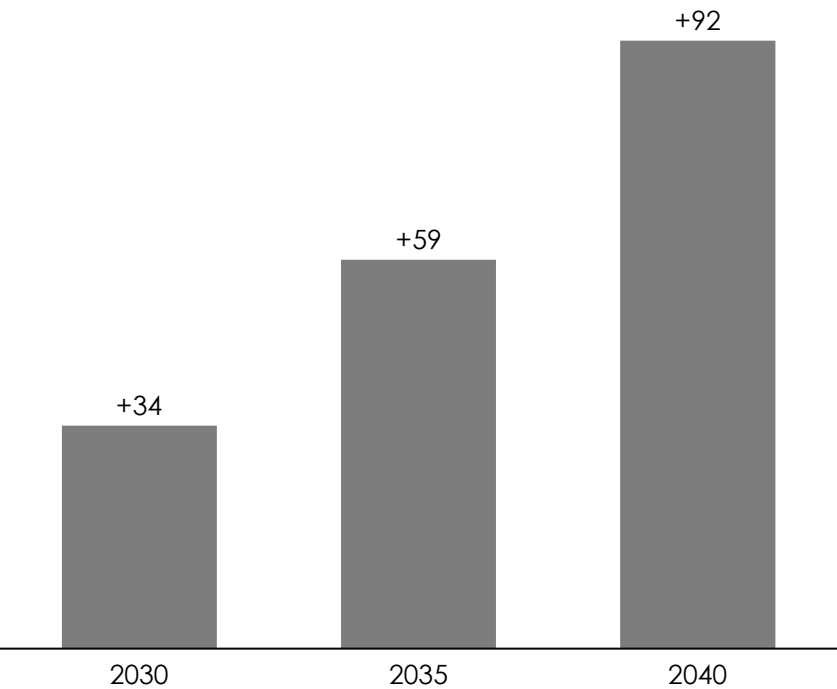
Source: Copenhagen Economics based on INTERSECT.

In the electricity doubling scenario, electrification can support an additional 92,000 jobs and EUR 23 billion in GVA in *Sweden* in 2040



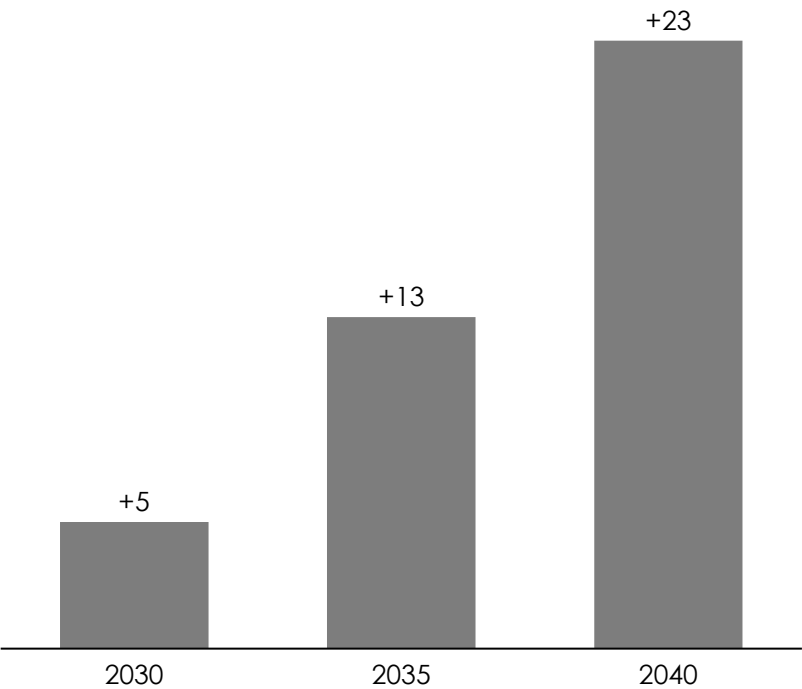
Total jobs from direct and indirect electrification – electricity doubling, relative to current levels¹

Thousand FTEs



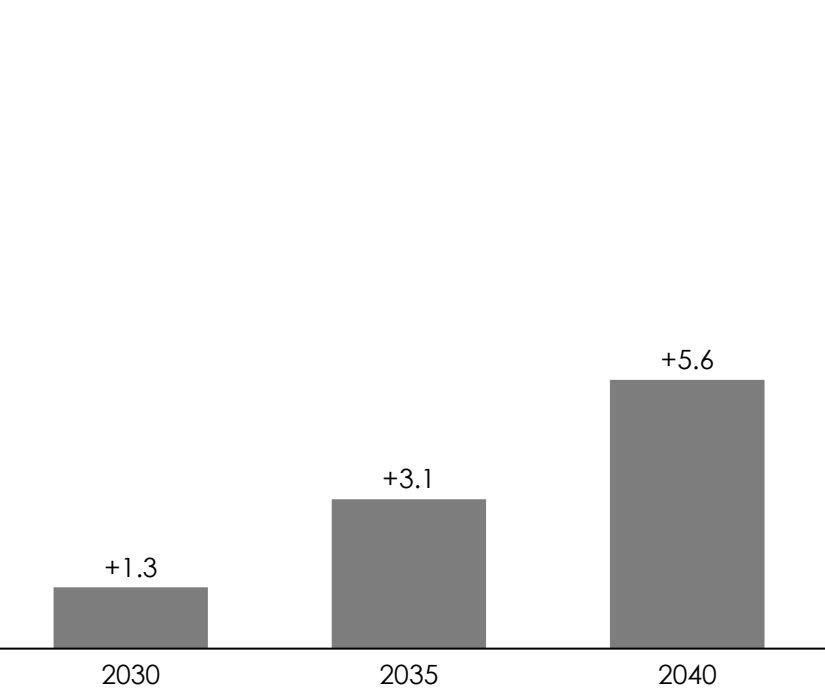
Total gross value added from direct and indirect electrification – electricity doubling, relative to current levels¹

EUR billion



Total taxes generated from direct and indirect electrification – electricity doubling, relative to current levels¹

EUR billion



Note: Taxes include corporate taxes and income taxation, based on the remuneration of labour and capital from the value added, and the average tax rates in Sweden. 2021-prices.
Source: Copenhagen Economics based on INTERSECT.

1) Current levels are based on 2021 inputs.

APPENDIX B: DESCRIPTION OF SELECTED MARKET INSTRUMENTS

COVERING INSTRUMENTS 2-6

Instrument 2: Market-wide capacity remuneration mechanism (CRM) (1/2)

With more intermittent energy from solar and wind entering the electricity system, the electricity supply will fluctuate more, and there is an increased need to ensure capacity adequacy. Capacity remuneration mechanisms (CRM) can be designed in different ways, but with this instrument, we focus on a market-wide CRM that can facilitate participation from both the supply- and demand-side.

A CRM provides payments to electricity producers in exchange for *availability of electricity production capacity* in times where electricity supply is lacking. Thus, CRMs serve as de-risking instruments in the energy transition. This differs from the current electricity market in Finland and Sweden, where only produced electricity is paid for (energy-only market).

A CRM can incorporate demand-side flexibility. For example, CRMs can compensate electricity consumers for lowering their consumption during peak hours, or over longer periods when capacity is low.

Several European countries have already implemented CRMs in different designs in terms of product types, financing, and level of centralisation, see table.

CRMs provide several societal benefits, including increased reliability, enhanced security of supply, a reduction in wholesale electricity market prices, and lower price volatility.¹

Capacity adequacy may become an issue already towards the end of the decade in Finland, and designing and implementing a CRM is a long process that can take years.¹ Design choices should be considered carefully to ensure that the possible capacity mechanism solves system adequacy challenges specific to Finnish and Swedish markets. Thus, if a decision is made to implement a CRM in Finland and/or Sweden, planning for it should start as soon as possible.

Overview of European CRMs²

Country	Capacity product	Financing	Centralised or decentralised	Targeted or market-wide
Belgium	Reliability option	Publicly financed	Centralised	Market-wide
France	Capacity obligation	Consumer financed	Decentralised	Market-wide
Italy	Reliability option	Consumer financed	Centralised	Market-wide
Ireland	Reliability option	Consumer financed	Centralised	Market-wide
Poland	Capacity obligation	Consumer financed	Centralised	Market-wide
UK	Capacity obligation	Consumer financed	Centralised	Market-wide

In Europe, there are multiple unique CRMs that are combinations of various design aspects of the mechanism. These include:

- **Reliability options** are one-way call options that are meant to incentivise generating electricity when the system is stressed. **Capacity obligations** are obligations that require generators to have enough capacity to meet a predetermined level.
- **Public financing** means that the expenses of the CRM are financed by a public entity. **Consumer financing** means that the expenses are financed privately, often by the consumer via the TSO.
- **Centralised** CRMs are mechanisms where the capacity product is allocated by one entity, often via auction. **Decentralised** CRMs allow for bilateral contracts between various market participants.
- **Market-wide** CRMs are technology neutral, meaning that any producer regardless of how they produce electricity can participate in the mechanism. **Targeted** CRMs are targeted towards a specific production technology, such as zero emission electricity production, e.g., NFFSS.

1) AFRY (2024), *How firm and flexible capacity supports Finland to become a green superpower* / 2) Compass Lexecon (2022), *Nordic power market design: A power market fit for Net Zero*, Elia (2024), *Capacity Remuneration Mechanism: General Info Session*, RTE (2021), *Retour d'expérience sur le mécanisme de capacité français*, European Commission, *Capacity mechanisms*, UK GOV (2013), *Electricity Market Reform: Capacity Market – Detailed Design Proposal*

Instrument 2: Market-wide capacity remuneration mechanism (CRM) (2/2)

CRMs are often implemented in response to market failures. In deregulated electricity markets, where electricity prices fluctuate due to varying supply and/or demand, there may not be sufficient financial incentives for generators to invest in and maintain capacity to be deployed only for peak demand, as they may not be able to recoup their fixed costs.

CRMs cover, for example, gas- or biofuel-fired electricity plants, energy storage (batteries, pumped hydro power). Contrary to a strategic reserve, CRMs are proactively forward-looking, and typically with long-term contracts.

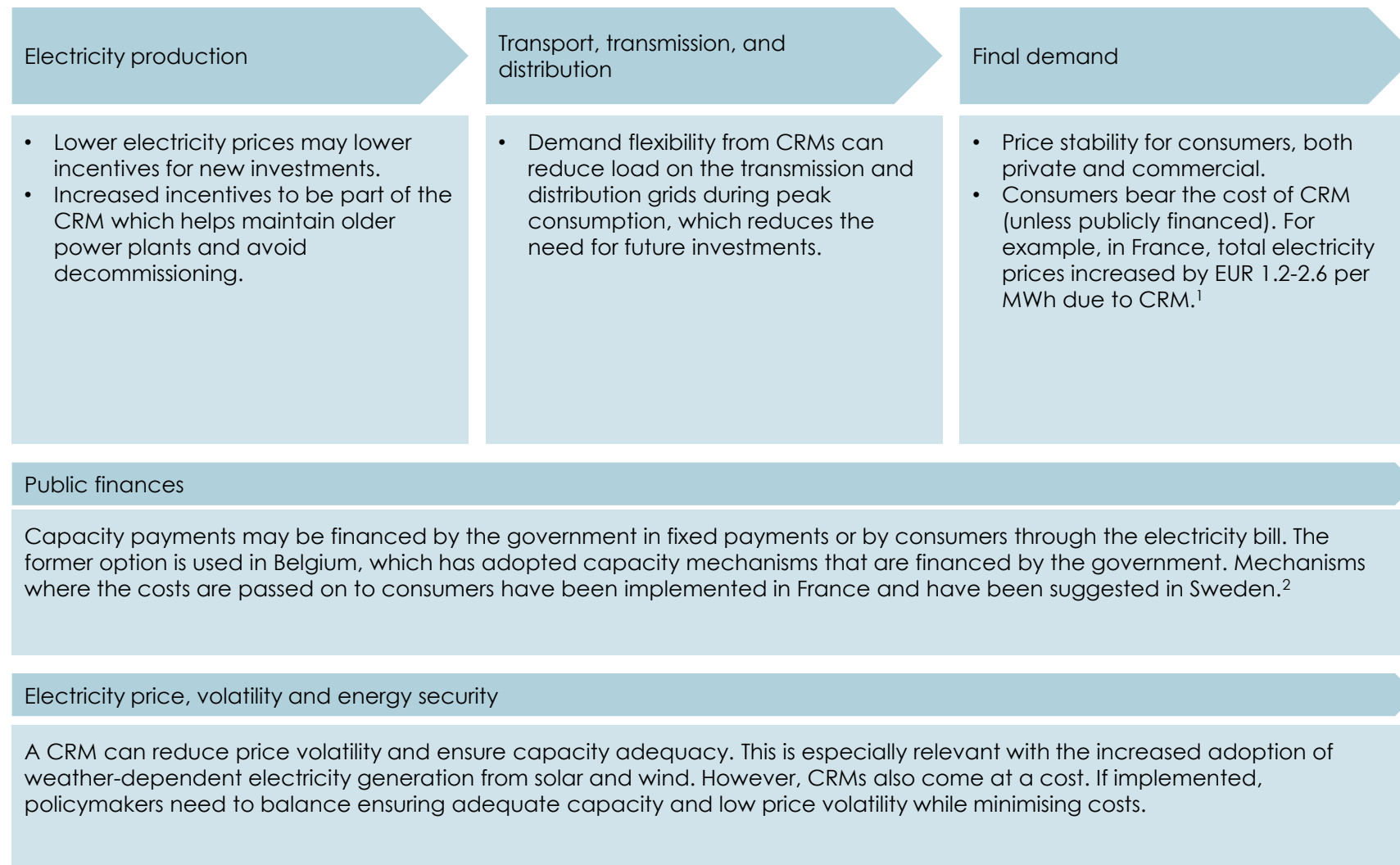
Impact

When implemented properly, CRMs can reduce price volatility and ensure capacity adequacy. The lower price volatility also reduces the risk for investors, particularly for:

- Some supply-side energy production investments, as their return is less volatile, but will also result in lower revenue from peak hours.
- Final demand, such as heavy industry with need for electrification investments, where the electricity price and price volatility of electricity significantly affects their profitability.

Capacity mechanisms also come with a cost, as compensation for the availability. This cost will either be paid by the government or by electricity consumers, for example for consumption during peak hours.

The instrument's impact on the electricity market value chain



1) During 2017-2019, CRM increased electricity prices by 1.2-2.6 €/MWh. Source: RTE (2021), *Retour d'expérience sur le mécanisme de capacité français* /

2) European Commission, *Capacity mechanisms*; Svenska Kraftnät (2023), *Främjande av ett mer flexibelt elsystem*

Instrument 3: Non-fossil flexibility support scheme (NFFSS)

A non-fossil flexibility support scheme refers to energy systems designed to balance supply and demand without relying on fossil fuels. This is a specific type of CRM.

These schemes cover new and CO₂-neutral capacity and demand flexibility. This could be (new) batteries, biogas or green hydrogen peakers, hydropower, nuclear power, and demand-side flexibility.

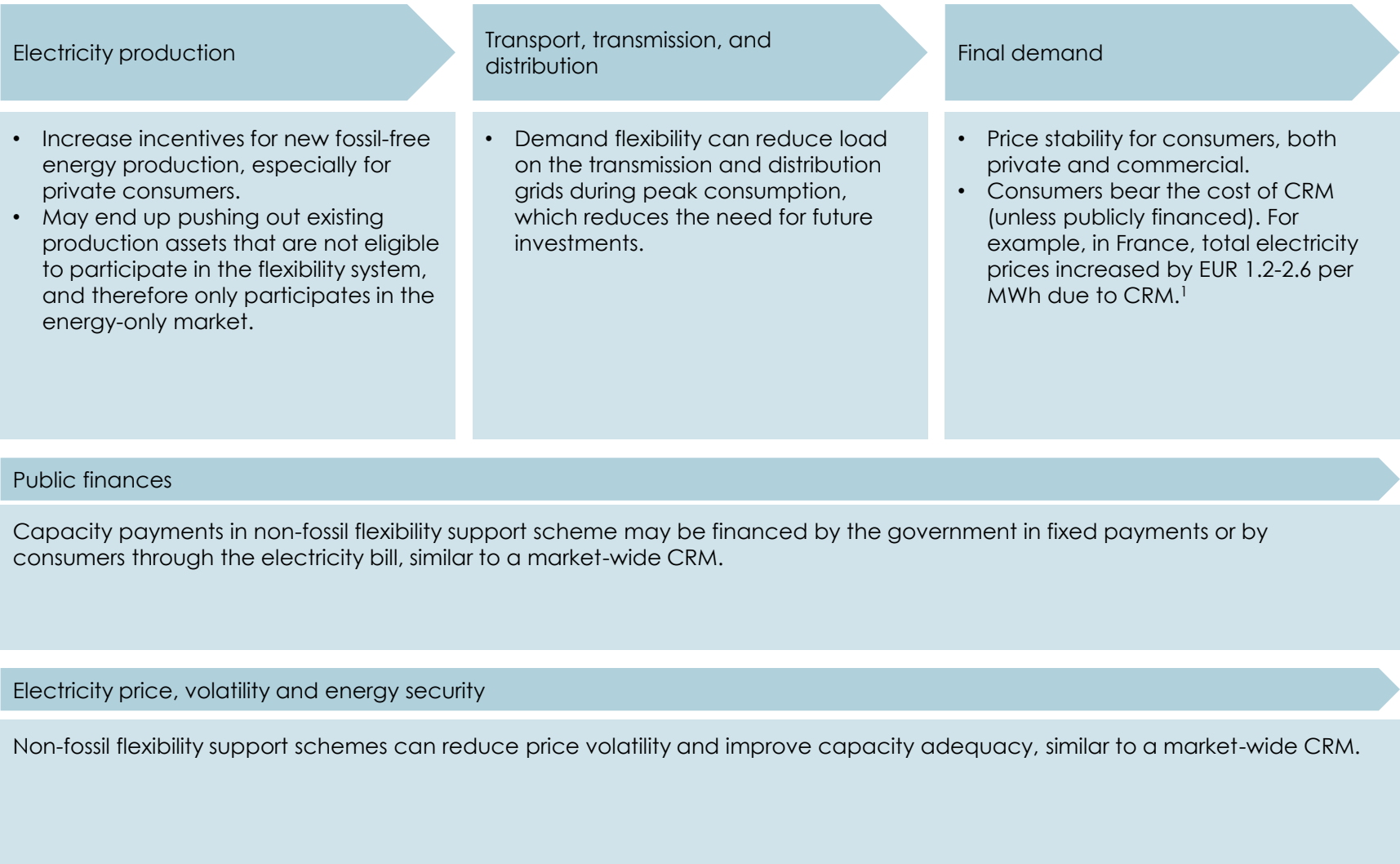
The European Commission has encouraged Member States to adopt non-fossil flexibility solutions in their reformed Electricity Market Design. However, they leave it up to the Member States to assess their own needs and introduce appropriate solutions themselves.¹

Impact

The goal is to ensure a stable and reliable energy supply while minimizing greenhouse gas emissions and promoting sustainability. In practice, this instrument can:

- Incentivise investment to fossil-free energy production.
- Enable consumers, both private and industrial, to better optimise their consumption according to energy prices, reducing price volatility and ensuring adequacy.
- Promote energy storage solutions while simultaneously reducing price volatility and improving security of supply.

The instrument's impact on the electricity market value chain



¹) European Commission (2023), *Commission welcomes deal on electricity market reform*

Instrument 4: Price derisking through publicly-backed power purchasing agreements (PPAs)

Publicly-backed Power Purchase Agreements (PPAs) are instruments that provide price security for green electricity producers.

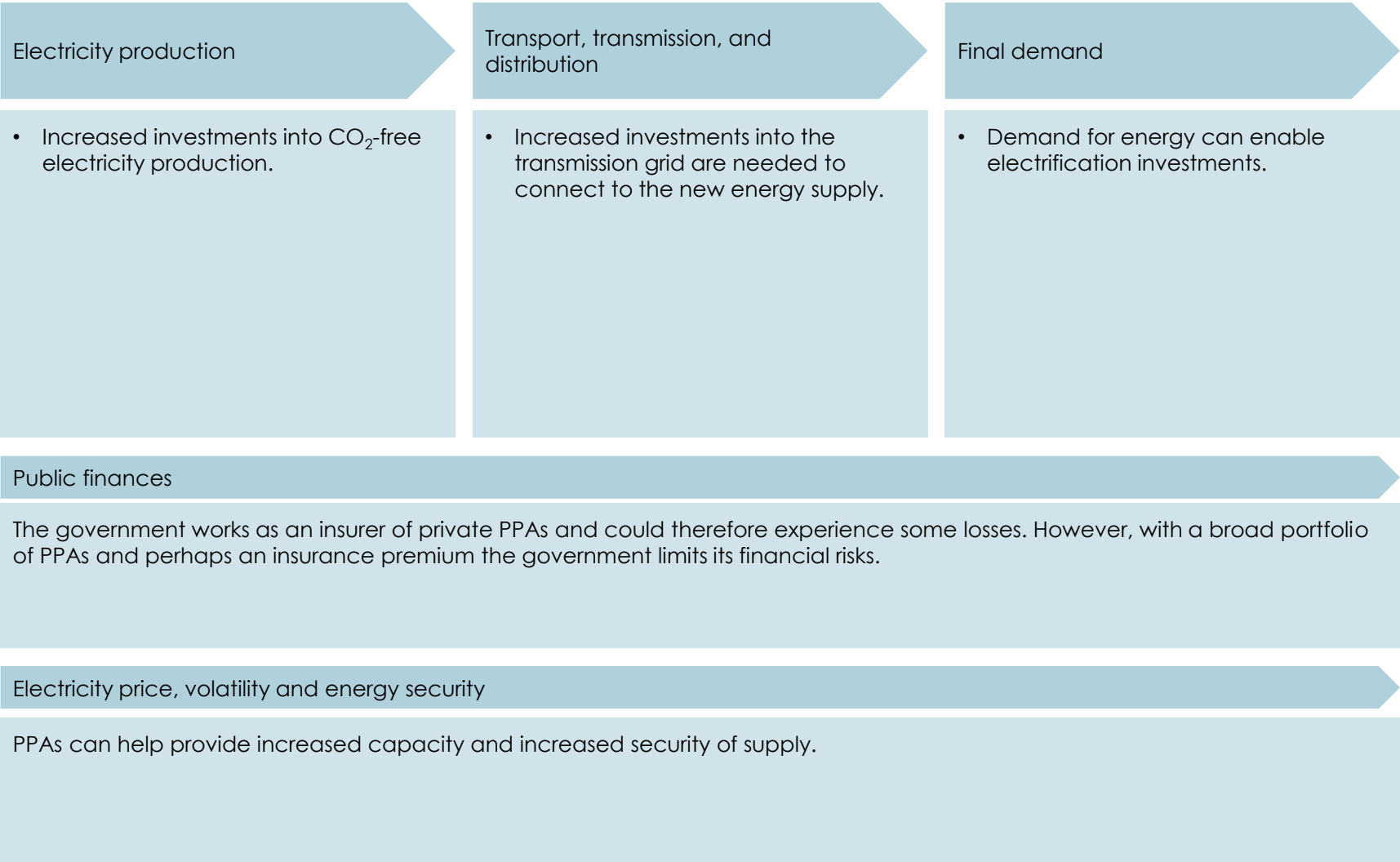
A PPA is a contract between an electricity producer and a consumer. For the duration of the contract, the customer purchases a pre-defined amount of energy at the agreed upon price. The price can be fixed or fluctuate according to market conditions, depending on the contract. When the PPA is publicly-backed, the government ensures the contract terms are fulfilled, also in case of defaults. Thus, the uncertainties are lowered for the parties engaged in the PPA.

PPAs are long-term contracts that typically last 10-20 years.

Impact

By fixing the price of an electricity producers' output, publicly-backed PPAs can reduce price uncertainty that energy producers may face for long-term investments, where the first revenue streams happen several years in the future. Additionally, publicly-backed PPAs can help small energy consumers in new industries engage in PPAs, even though they have limited private financial backing. This can mitigate risks associated with building new renewable electricity plants, such as Power-to-X, thus encouraging investments into electrification and CO₂-neutral energy production.

The instrument's impact on the electricity market value chain



Instrument 5: Price derisking through Contract-for-Difference (CfD) auctions

Contracts for Differences (CfDs) are instruments that provide price security for green electricity producers of renewable energy and nuclear power.

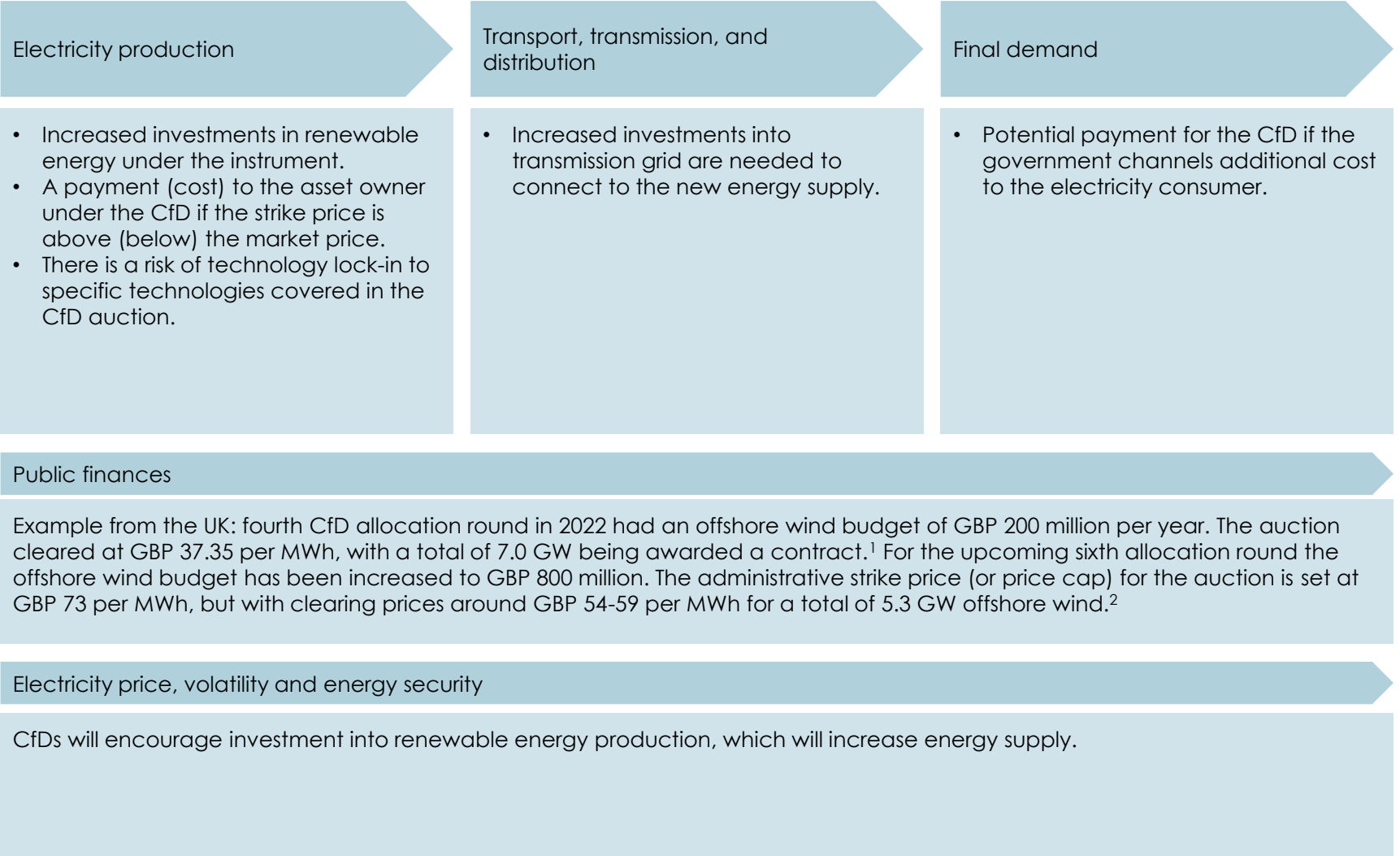
Two-way CfDs are typically used to incentivise offshore wind and nuclear plants. A public entity agrees to pay the difference between the agreed *strike price* and the market price. Effectively, this sets a fixed price for an energy producer's production. This significantly reduces price uncertainty, and the overall risk associated with building an offshore wind farm or a new nuclear plant, which lowers the cost of capital and increases project bankability.

CfDs are long-term contracts that typically last 10-20 years.

Impact

By fixing the price of an electricity producers' production, CfDs can reduce price uncertainty that energy producers may face. This mitigates risks associated with building new renewable electricity plants, and thus encourages investments in new CO₂-neutral energy production.

The instrument's impact on the electricity market value chain



1) UK Gov (2022), *Contracts for Difference (CfD) Allocation Round 4: Draft budget notice* and UK Gov (2022), *Contracts for Difference (CfD) Allocation Round 4: results*. / 2) UK Gov (2024), *CfD Allocation Round 6: Budget Notice* and WindEurope (2024): *UK awards 5.3 GW of new offshore wind and 990 MW of new onshore wind*

Instrument 6: Geographically differentiated tariffs

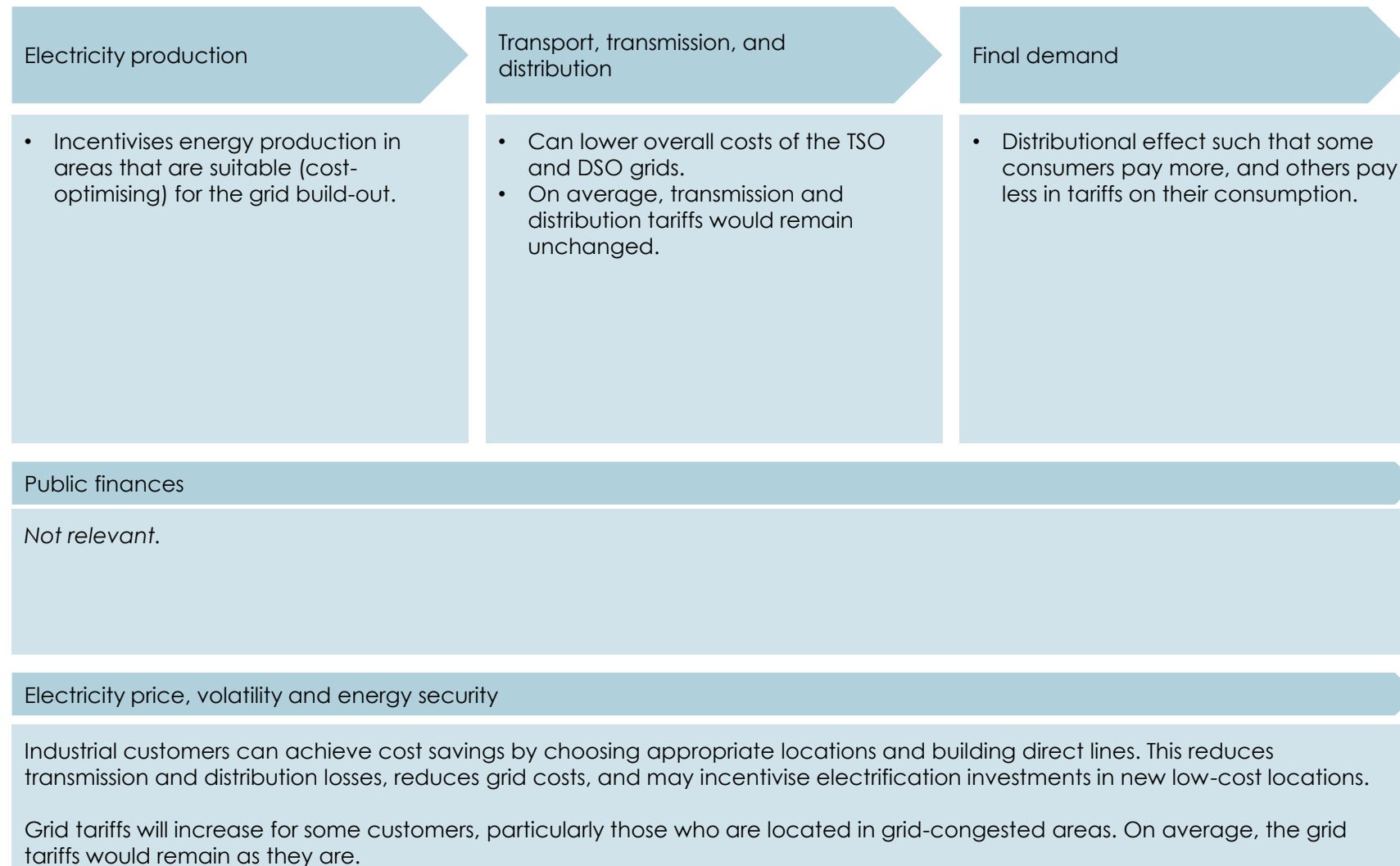
Geographically differentiated tariffs refer to the differentiation of tariffs to encourage placing demand in specific areas.

Geographically differentiated grid tariffs allow TSOs and/or DSOs to more accurately convey the actual transmission operator costs of each consumer.

Impact

Geographically differentiated tariffs allow TSOs and/or DSOs to convey more cost-effective price signals to consumers, so that consumers pay tariffs that are in line with what costs incur for the DSO/TSO. They would also incentivise building high-consumption industrial projects near energy production, improving efficiency.

The instrument's impact on the electricity market value chain



APPENDIX C: METHODOLOGY DESCRIPTION

- **INTERVIEWS WITH CONSUMERS OF ELECTRICITY**
- **THE CE CLIMATE ECONOMIC MODEL, INTERSECT**
- **THE CE POWER MARKET MODEL**
- **REFERENCE LIST**

Methodology: Interviews with consumers of electricity

We held five interviews with consumers of electricity in Finland and Sweden in May 2024.

We used the information from these interview to help understand electrification investment decisions (chapter 1), but also what obstacles in the current market design that stand in the way of these investments materialising (chapter 2).

Below is a description of some of the information gathered from the interviews.

In the interviews, we focused on various aspects of electrification investments in industry processes, transport, heat, and Power-to-X in Finland and Sweden. The discussions revolved around the current use of electricity in different industries, both direct and indirect electrification.

Participants shared insights on their industries' possibilities to be flexible in production, such as one industry's ability to produce less during demand peaks and more at night, and the challenges faced by industries that cannot be as flexible.

The interviews also touched on the increasing demand for electricity, driven by factors like increased hydrogen demand and carbon capture and storage (CCS) initiatives.

Key decision parameters for investing in Finland and Sweden were discussed, including the unique starting point of having hydro and nuclear power, the potential for nuclear in the future, and the concerns around the

scarcity of future power supply. The interviews highlighted the significant challenges faced by members in pursuing electrification, such as capacity issues in the grid, investment costs, electricity prices, price volatility, as well as technical issues.

In the interviews and from our desk research, we find that the drivers of electrification investments are:

- Overall political targets
- Carbon pricing (ETS)
- State-aid supporting novel technologies, such as Power-to-X (e.g., Hydrogen Bank)
- Low and stable electricity prices and a well-functioning electricity market

For the investments to materialise, there is a need for:

- Long-term political *certainty*, including specific targets
- Investment plans for necessary infrastructure in grid and Power-to-X infrastructure
- Faster permitting throughout the value chains
- A suitable market design that enables electrification investments and the needed infrastructure

Overall, the interviews provided valuable insights into the drivers behind electrification investments, the challenges

encountered for electrification investments, and the potential solutions or strategies considered by industry members to overcome these challenges. We have used these insights in our analysis in chapter 1 and 2.

Methodology: The CE Climate Economic Model, INTERSECT (1/3)

The decarbonisations of the Finnish and Swedish economies require significant investments towards 2040. These electrification investments will in turn create and sustain jobs, add value, and taxes in direct and indirect electrification of current industries in Finland and Sweden, as well as in new industries, such as Power-to-X.

We estimate these investment needs in INTERSECT. INTERSECT is our internal **Computable General Equilibrium (CGE) model**, see below.¹

INTERSECT is a macroeconomic model covering climate and energy aspects. The underlying data includes final consumption, production using capital and labour usage,

and the CO₂ intensity of production.

The model offers a unique opportunity to analyse impacts because it takes a holistic approach to the entire economy, thereby avoiding a partial view for one sector only. We consider several key features using INTERSECT:

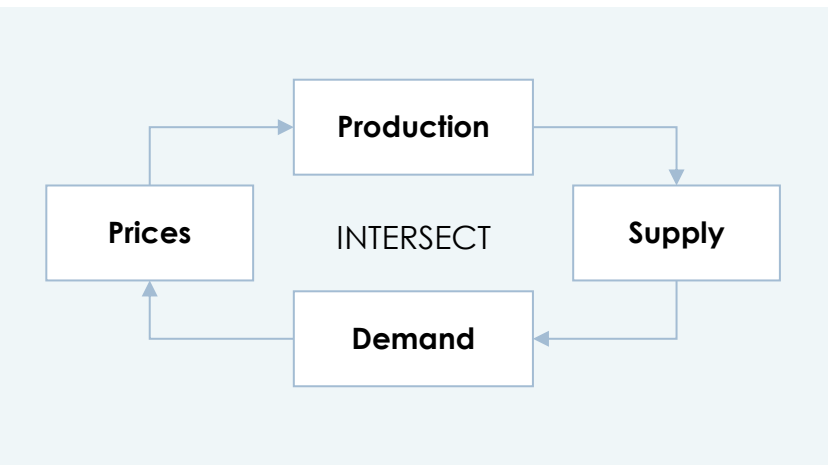
- i. We simulate how industries, households, and countries trade with each other given relative prices and incomes.
- ii. We analyse how the value chain operates from electricity production to hydrogen production, as well as hydrogen's uses in other industries.

- iii. We distinguish between different climate scenarios with different decarbonisation targets.
- iv. We analyse results on annual basis towards 2040, where industries and households choose the optimal level of production and consumption, given the constraints in the economy.
- v. We arrive at results where investments in green technologies are driven by CO₂ prices and lower technology costs for green solutions.

Drivers of change

Decarbonisation targets
Technology change
Economic growth
Policy and regulation

Economic forecast module



Selection of insights

GVA, jobs, tax contributions
Technology and industry change
Investment flows
Costs developments

1) We do not cover specific plant-level investments but rather investment made on a sector level. See Appendix C for a further description.

Methodology: The CE Climate Economic Model, INTERSECT (2/3)

About the model:

- INTERSECT is developed by Copenhagen Economics together with Bain & Co.¹
- It is rooted in **economic theory** and extended to **account for carbon emissions** and allows for technology choices in a large range of industries.

How it works:

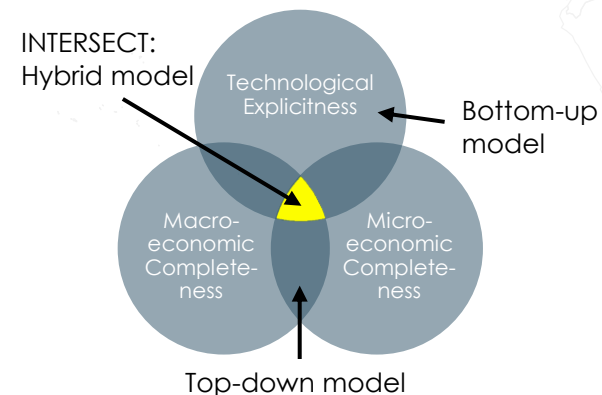
- INTERSECT has **global coverage spanning 17 regions (here also Finland and Sweden separately) and 33 industries** allowing for simulations up to 2050, and specific national analyses.
- INTERSECT integrates carbon emissions centrally, offering insights into detailed **decarbonization pathways** and their economic impacts.

- It employs an **integrated hybrid approach** that combines the classical welfare-maximizing macroeconomic top-down method with a bottom-up cost-minimizing treatment of technology.

Full value chain

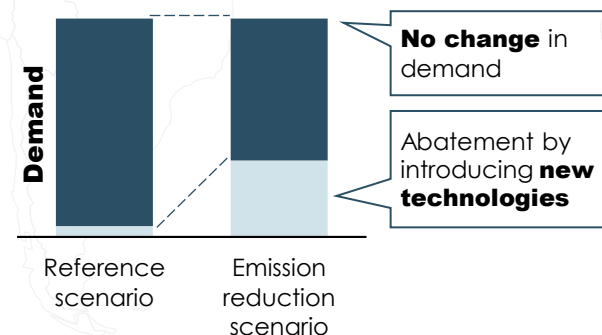
- INTERSECT captures the **full value chain** as it models production, consumption, employment, investment, taxes, trade, and their linkages.
- The model is based on a **comprehensive macro-economic data foundation**, detailed emission data, known policies, and industry trends, with an ability to update to reflect specific industry insights or policy interventions.

The hybrid model approach



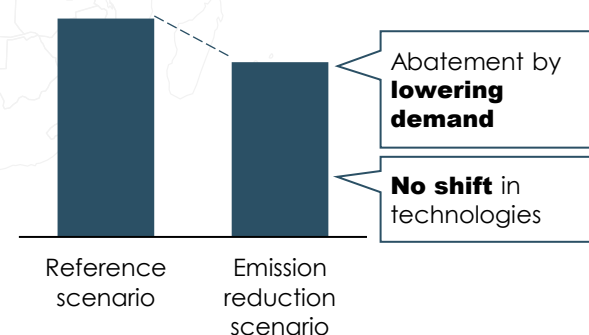
Bottom-up model

- Ignores substitution possibilities across consumption goods
- Underestimates loss of welfare



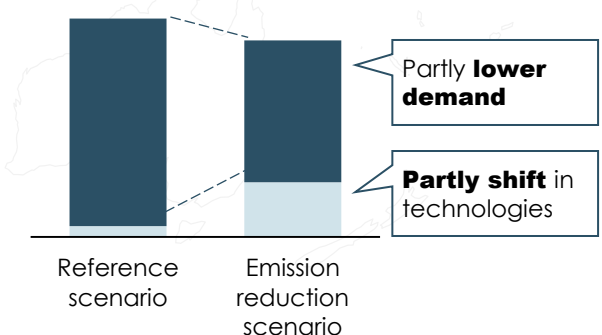
Top-down model

- Ignores technological switch within demand of sector
- Overestimates loss of welfare



INTERSECT: A hybrid model

- Allows for **technological switch** within sector and **substitution** across consumption goods



¹ See Copenhagen Economic (2023), *Navigating the complexities of the green transition: our considered approach to risk analysis* and Copenhagen Economics (2023), *An affordable green transition: The What and the How*.

Methodology: The CE Climate Economic Model, INTERSECT (3/3)

Three scenarios: delayed electrification, ambitious decarbonisation, and electricity doubling

Scenario 1:

Delayed electrification

- **Description:** Countries decarbonise following their current stated policies (the IEA STEPS scenario).
- Sweden and Finland decarbonise following a relaxed path of their current targets with slow initial uptake of renewable technologies.
- Sweden will not implement new nuclear before 2040.

Scenario 2:

Ambitious decarbonisation

- **Description:** Countries decarbonise to reach global net zero emissions in 2050 (the IEA Net Zero Emissions scenario).
- Sweden and Finland decarbonise to reach net zero in 2045 and 2035, respectively.
- The EU hydrogen strategy is fulfilled, such that the EU produces 10 million tonnes and imports 10 million tonnes of renewable hydrogen by 2030.¹

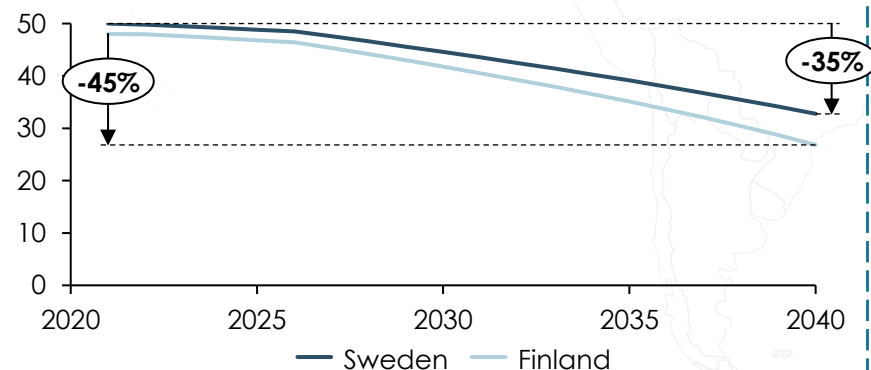
Scenario 3:

Electricity doubling

- Scenario with targeted 2040 electricity production levels around **300 TWh in Sweden** and **160 TWh in Finland**.
- **No limits** on expansion of production capabilities in wind and solar – hydro and nuclear follow same path as *Ambitious decarbonisation*.
- **No limits** on expansion of production of renewable hydrogen and exports to Europe.
- **In Finland**, we have manually adjusted electricity production and hydrogen production down to align with an electricity production of 160 TWh.

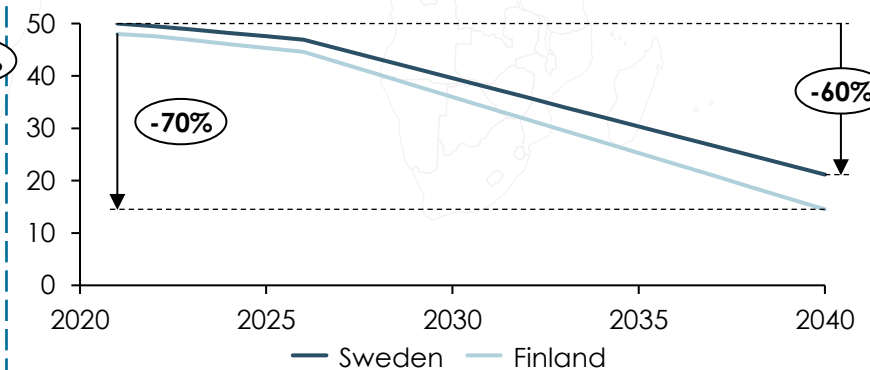
CO₂ emissions – Not including natural LULUCF

MT CO₂



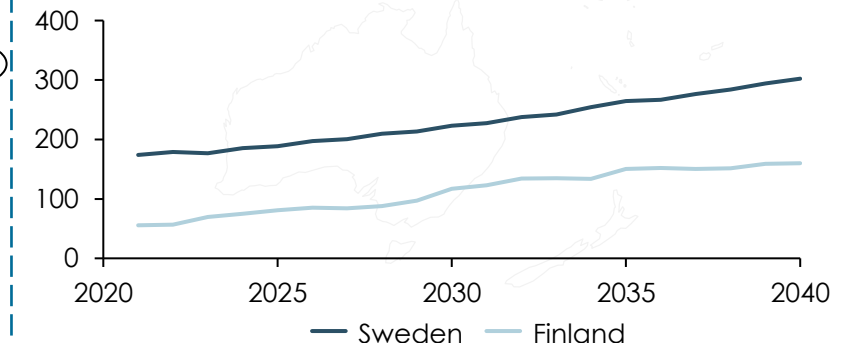
CO₂ emissions – Not including natural LULUCF

MT CO₂



Electricity production in the electricity doubling scenario

TWh



¹) European Commission: Hydrogen

Methodology: The CE Power Market model

About the model:

- The CE Power Market Model is a partial equilibrium (dispatch) model for the day-ahead European wholesale electricity market.
- The model minimises the total electricity system cost in the specific markets – here Finland and Sweden – under exogenous variables, including demand and capacity constraints.
- In the model, we simulate wholesale prices, electricity mixes, trade, hydro storage, etc. in an hourly resolution using the principle of merit order dispatching where the marginal cost determines the market equilibrium price for each hour.
- We have calibrated the model with 2023 data in Finland¹ and the four bidding zones in Sweden (SE1-SE4) and have

used this as the point of departure for counterfactual experiments.

- We have evaluated two different market instruments and their effect on price levels and price volatility.

Market instruments:

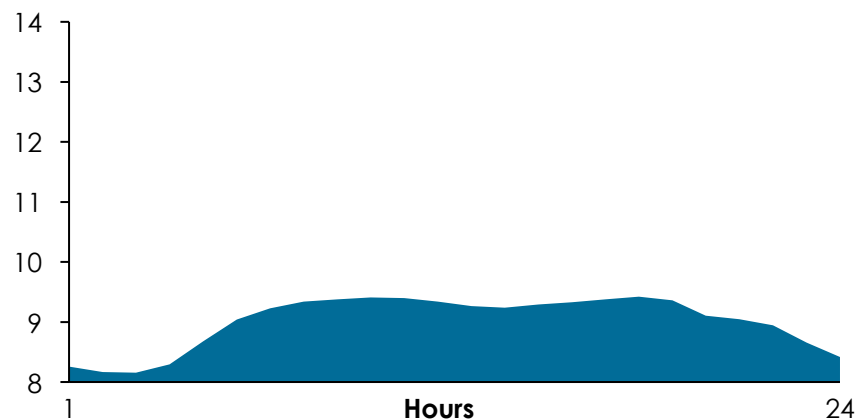
- **Demand side response:** 150 MW demand flexibility that can be activated when prices reach 5 per cent and again at 1 per cent highest in Finland and SE3. The instrument is available throughout the year.
- **Seasonal CRM:** 500 MW capacity that is available in January in Finland and SE3. To make the model function, the capacity bids with a marginal cost of 0 and is remunerated off-market (outside of this model).
- We have tested the effect of the two instruments in the

2023 market and a market resembling 2030. We have used INTERSECT output to scale 2023 supply and demand to 2030 levels.

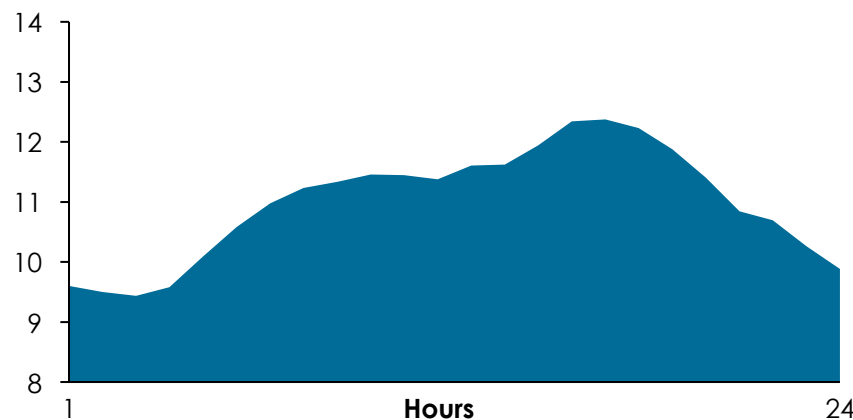
Scaling to 2030 numbers:

- **Demand:** We have increased demand with ~20 per cent in Finland and ~10 per cent in Sweden relative to 2023 data, based on the ambitious decarbonisation scenario. We have estimated two possible load profiles for a flexible and a non-flexible scenario, see the figures for Finland below.²
- **Supply:** We have increased wind and solar capacity by 70 per cent in both Finland and Sweden. We have increase nuclear capacity with 10 per cent in Sweden and reduced fossil capacity with 50 per cent in both countries.
- For simplicity, we have assumed exogenous prices and marginal production costs to remain at the level in 2023.

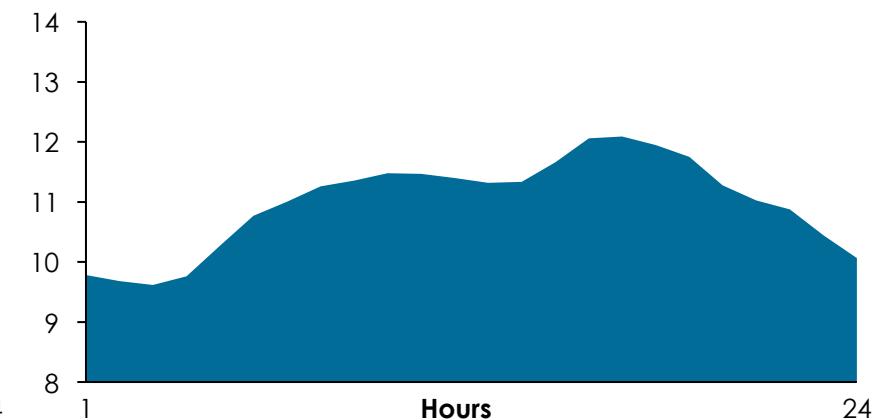
Finland 2023 average load profile, GW



Finland 2030 average non-flexible profile, GW



Finland 2030 average flexible profile, GW



1) In the figures, we show some of the results for Finland. Similar analysis has been made for the Swedish price zones.

2) Using EA (2023), Value of Demand Flexibility in the European Power Sector and Eurelectric (2021), Connecting the dots: Distribution grid investment to power the energy transition.

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