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Sector integration overview

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Introduction

Energy sector integration refers to innovations and technology aiming to link production and the use of energy in electricity, transport, heat, and industry. The goal is to help decarbonise sectors that have troubles decreasing emissions by themselves, increase security of supply and cost efficiency. The target comes from tackling climate change and the need to cut emissions to net-zero and then quickly to negative emissions. To reach the target, all sources of energy must be utilised. This requires different sectors to cooperate better and to exploit all possible energy sources. Also, silos between regulators must be removed and broaden the understanding of where energy comes from. This requires better cooperation between regulators and openness to new ideas.

This literature review will discuss the definition of the term, explain upcoming trends and legislation at EU level, present examples from the Finnish market and look at future enablers. The review will end with a discussion about future developments. The goal is to understand the bigger picture of the topic. However, as a research question this topic is quite novel and sources were difficult to find. Therefore, only a few research articles were used as references. This also shows how new the topic in question is as a concept and that it is difficult to say where the development will end up.

EC's Energy System Integration Strategy

The word sector-integration is new in this context. Therefore, it is used differently by different stakeholders in different industries, often in a way that favours the particular player. Now, it is important to define the terms. The starting point should be that everyone understands the used terms similarly. Otherwise, discussions will get even more difficult with higher risks for misunderstandings. This is largely a communication issue, that should reach people from the energy industry, but also other industry specialists and individual consumers, who can profit from sector integration. To understand the use of the term and its wide scope, this chapter discusses the term from different perspectives based on EU Commissions sector integration strategy and stakeholders' position papers.

The EU Commission released its strategy on sector integration 8th of July 2020. The starting point is The Green Deal helping EU to reach its goal of carbon-neutrality in 2050 (European Commission, 2020). The strategy states that the energy system is vital for reaching the goals. It describes the energy future to be more decentralised, renewable, and integrated, while continuing to be resource-efficient, minimise pollution and biodiversity loss. The strategy builds an understandable definition of the term and uses that as the starting point for the rest of the strategy.

“Energy system integration – the coordinated planning and operation of the energy system ‘as a whole’, across multiple energy carriers, infrastructures, and consumption sectors” (European Commission, 2020, p. 1)

Building on the quote, the strategy introduces three concepts: 1) a circular energy system emphasising energy efficiency, 2) increased electrification of end-use sector 3) use renewable and low-carbon fuels in end-use applications where direct heating¹ or electrification is not feasible. The first prioritises the least energy intensive option, the use of energy waste streams and exploits synergies across sectors. The second relies on rapid growth and price decrease of renewables and the third discusses areas that are difficult to electrify. It can also become a part of energy storage and stabilise the volatility caused by intermittent renewable energy sources. In addition, the energy system of the future is multi-directional, and consumers play a larger role. The strategy strives to simultaneously decrease emissions and increase the competitiveness of the EU. The goals will open business opportunities for companies and drive EU's leading position in cleantech.

¹ Finnish Energy asked for the meaning of direct heating from the Commission but did not get an answer. Our guess is that it should be district heating.

The strategy will be implemented through six pillars discussed in chapter 3 of the strategy: 1) a more circular energy system, 2) accelerate electrification, 3) promote renewable and low-carbon fuels, 4) fit energy markets to decarbonisation and distributed resources, 5) further integrated energy infrastructure and 6) digitalisation of the energy system and innovation supportive framework. All the pillars include background information, enablers and a key action box.

The first pillar concentrates on energy efficiency and then waste heat, together with circularity. Increased energy efficiency decreases the energy usage and therefore, it is a first principle throughout. Also, investment should be made on the demand side when feasible. The mentioned tools include the use of Primary Energy Factor (PEF), Renovation Wave, encourage circularity with the use of waste heat and further use of wastewater and biological waste for bioenergy production.

The second pillar discusses the electrification of the society and the following increase of electricity usage. To reach the desired goal, the increased demand of electricity must be supplied with renewable electricity. This requires massive investments and tackling of remaining barriers, including underdeveloped supply chains and smart grids at national and international level, public acceptance, lengthy bureaucracy, financing, or high cost for less mature technologies. This pillar also discusses the possibilities of offshore electricity production together with joint hydrogen electrolyzers. In the short term, EU will use the Next Generation EU recovery instrument for further investments in renewable energy. The strategy expects further use of heat pumps, in the residential and service sectors, and district heating and cooling. The largest barrier is the unfair taxation of heat pumps compared to fossil fuels. In industry and transport, the investment costs of electric solutions are higher than traditional solutions and therefore unattractive. Most related legislative proposals from the Commission are expected during 2021, the whole list of key actions is in Appendix 1.

Everything is not feasible to electrify and therefore, the third pillar encourages the use of low-carbon and renewable fuels, including hydrogen. These fuels will play an essential role in maritime and aviation for example. Hydrogen use lack polluting emissions and is therefore an interesting opportunity as fuel. However, the market share is still small and renewable hydrogen almost non-existent. The market has to be created and low-carbon hydrogen will be a part of the transition. The Commission considers minimum shares of renewable hydrogen in some sectors to promote the development together with financial support. This pillar also discusses the use of carbon Capture and Storage (CCS) as a part of the system as a whole and of low-carbon hydrogen. In addition, one suggested cornerstone is the development of a carbon removal certification system to be able to trace said carbon emissions.

The fourth pillar aims for energy markets that guide customers toward the most energy efficient and cheapest decarbonisation option. The market should consider all the costs of the energy in question, this also includes indirect costs. The goal is to counteract the trend of taxes and levies being higher for electricity than for fossil fuels. In addition, carbon prices are not high enough to act as a decarbonisation incentive. Another barrier is double taxation of energy or double grid charges. Consumers should be informed about their choices in electricity, gas and district heating alike.

The fifth pillar talks about physical links between energy carriers. The goal is to exploit existing networks, but simultaneously not lock into a specific technology. In addition, low temperature district heating networks are promoted, electricity grids should be used more efficiently, and gas grids offers the opportunity to increase the use of renewable gases. However, further integration can mean that disruption spreads from one network to another. Therefore, security questions have to be developed further.

The sixth pillar builds on all of the others and discusses the digitalisation of the energy system and an innovation permissive market. Digitalisation is key for dynamic energy flow between the interlinked network and also to match the demand and supply over a more diverse system. On the other hand, the increased ICT equipment increases electricity demand and raises questions about ethics, privacy, and cybersecurity.

Also, initially the word sector-coupling was used. It referred to the coupling of the electricity grid and gas network, by for example electrifying transport and industry, and storing excess electricity together by producing synthetic fuels. The goal was the same as for sector integration now, phasing-out the use of coal. However, in a briefing to the European Parliament (Erbach, 2019, p. 4), the words sector-coupling and sector integration are used as synonyms. Therefore, it is not surprising that the definitions for the terms are difficult to grasp. Furthermore, the new strategy released in July 2020 talks about Energy System Integration.

The content is a compromise between the commission, council, and the parliament, as well as statements from different stakeholders. Implementation relies on how different sectors adopt the strategy. Therefore, to understand the view of stakeholders and different sectors better, some position papers, posted as feedback before the release of the strategy, will be discussed next.

Stakeholders' views

The European Commission gave the opportunity to comment on the Energy System Integration Strategy along the way. Hundreds of comments were admitted, and this section aims to bring the views from different perspectives and stakeholders.

Finnish Energy's (Energiateollisuus (ET) in Finnish) (2020) comment on the European Commission's consultation was mostly positive toward integrating different energy sources, and transport and industry. It highlights opportunities for cost-efficiency and reduction in carbon emissions. Sector-integration will increase electrification and hydrogen will play a role where electricity is difficult to utilise. Also, CCS may be a possibility. The EU should continue to develop its Emission Trading System (ETS) to all sectors to cut emissions. Finnish Energy is concerned if the possibilities of energy networks are fully understood. Up to date networks (transmission and distribution) allows large-scale and on-site smaller solutions to work together where they are the most efficient. In addition, the paper discusses the importance of market-based new technology. Also, taxation largely effects what energy sources are viable and should be planned to allow new types of energy conversion, like power to x (P2X).

Council of European Energy Regulators (CEER) (2020) is also positive toward sector-integration in energy, transport, and industry. Their answer emphasises cost-efficient decarbonisation through cross-sectoral and a whole system approach. Especially the latter topic is important throughout the statement and points to development with a wider scope than only the company's own network. It includes development of heat, gas, and electricity in the best possible way. However, most emphasis is put on gas and electricity. Today, optimisation concentrate only on parts of a grid and can cause negative effects on the grid as a whole. The statement overall emphasises the role of network operators and acknowledges the possible challenges of increasing intermittent renewables, lack of cooperation between regulators and taking decisions in a market with high uncertainty. Another point is the role of final consumers, the size of their energy bills and their rights. Also, the importance of energy storage will increase as the share of intermittent renewables increases. In addition, digitalisation will help to increase efficiency, enable new services, platforms, and marketplaces transforming the sector.

Eurelectric's (2020) input to the sector integration strategy enhanced the importance of electrification and its possibilities to decrease emissions. It also reminds about the commitment of the European electricity sector becoming carbon-neutral well before 2050. However, to reach the goal, the market should be stable for long-term investments and build on market-based frameworks. The transition should also increase energy efficiency and demand response possibilities, enhance synergies further between sectors and not leave anyone behind. Main tools for this should be the EU ETS, quick and wide implementation of the Clean Energy Package, keep regulation technology open and work on public acceptance. Sharing of best practices must become more frequent by increased dialogue. In addition, the paper states that power-to-gas will be needed, and this requires drastic changes in energy usage, production and transport. One mentioned key link is the coupling of electricity and gas sectors, but also the integration of energy and heat sectors is mentioned.

Energy Cities (2020) highlight the importance of synergies between district heating networks, gas grids and electricity systems. The use of renewable electricity should increase, but so should the recovery of waste heat and development of renewable heat. Their contribution shares the progress of cities and member states with widely developed district heating systems. In addition, the paper underlines the importance of the importance of linking renewable electricity with district heating. However, the main barriers exist in the same areas that are emphasized as the most important areas for decarbonisation. The largest seem to be lacking linkages between different energy supplying and using sectors. Connected to this, policies are often planned for one particular sector and therefore, stops further cooperation. The lack of cooperation is present in all the other presented barriers, for example, traditional top-bottom approach to energy systems, lacking cooperation between governance levels and differences between heating and cooling, and electricity sectors' regulations and business models.

Euroheat & Power (2020) commented after the strategy release that it recognises the potential of district heating networks and the need for financial support to actual realise all the wide possibilities with the network. The strategy discusses the importance of the use of waste heat in district heating networks and also the networks ability to be a part of a smart energy system through examples. The latter has been made possible by integration with the gas and electricity grids. The examples show that district heating networks are a strategic asset to Europe, not only a local solution. The organisation thinks that they have gotten their message across to the strategy writers.

European Data Centre Association (EUDCA) (2020) brings up the quick increase in the data centre market during the past 25 years. They represent a large user of electricity in the EU, but they also show huge progress in energy efficiency. According to the EDCA, most of the growth in data centres can be attributed to businesses moving from traditional servers in their own premises to cloud-based services. The paper gives a view of a misunderstood field, that often is blamed for their large energy consumption. However, they stand up for themselves by stating that energy costs are the second largest expense in running a data centre. Therefore, they are obsessed with energy efficiency. In addition, many recycle the waste heat and aim at reducing the waste from cooling water. The field is also very important to fulfil all the digitalisation goals. The increasing use of renewables and smart grid management are part of the energy transition and also, protects data centres from outages and stabilises the grid. The field wants enabling legislation, awareness raising and support from the next MFF.

Overall, the strategy covers electricity, gas and heat on a general level and paints a greener picture of the future with lower emissions, healthier citizens and improved biodiversity. The path to carbon-neutrality is through energy efficiency, electrification, and the use of renewable and low-carbon fuels. All the referenced position papers discuss, in general, the same things as the strategy. However, the discussion is on a very high level and the details are missing. It is a good thing that the strategy recognises one model does not fit all, but it could be a problem to write directives on EU level that allows all the possible different solutions. The largest differences are visible in the different views of energy producers and users. For example, EUDCA wants more recognition of the specific field. This could be the view of other industries too but would require further research to find the differences. Also, the corona pandemic caused an economic crisis and sector-integration should be the way to rebuild the economy.

Upcoming trends

Sector-integration have existed for long already. For example, combined heat and power (CHP) is a traditional way to produce both heat and electricity, and simultaneously increase the efficiency. However, the use of excess heat is increasing and the possibilities in sector-integration are tremendous. This chapter will look into the bigger picture at EU level, including regulations and their release schedule, and some concrete examples, and then narrow the scope to Finland, for a closer look.

Bigger picture – EU level

Von der Leyen's European Commission (EC) that stepped into office in late 2019 introduced the Green Deal as one of their main goals. It is a growth strategy that considers nature and society. It aims to make EU a net-zero emitter by 2050, decouple growth from resource use and protect the European natural capital (European Commission, 2019). The Green Deal will heavily lead the ECs work during its five-year period. The energy-related emissions are 75% of all emissions (European Commission, 2019). Therefore, the energy sector has a large role to play to fulfil the Green Deal and the new sector integration strategy plays as the starting point. It allows the use of previous excess energy and forces negotiating regulations as a cooperation between different industries. The latter has been proven difficult several times. Now, regulations are done in silos for one industry at a time and therefore, cooperation is strained by regulations.

The electricity producers in the EU have managed to remarkably cut emissions, but other areas, such as, heat and transport, have been slower. Therefore, one often discussed alternative is electrification of several industries, as discussed earlier in the energy system integration strategy. Also, the progression of sector-integration will change how we see energy and its use. This chapter discusses the bigger picture in the EU and then looks at concrete examples in Finland.

Progress in EU

The EU is taking large steps towards a greener future. The previous Commission introduced the Clean Energy Package. Now, the European society has greener values and gives the current EU Commission a more opportunities for green legislation compared to the previous. They started their period by releasing the EU Green Deal (European Commission, 2019), which should show way for the whole 5-year period. Until 2018, emissions decreased by 23% while the economy grew by 61% (European Commission, 2019). Going green has progressed furthest in electricity production. Therefore, electrification is seen as a solution to cut emissions in many industries. The already released Energy systems integration strategy paints an optimistic picture of the future, but the critical discussion of how to actually reach the goal is lacking. The change is tremendous and requires a change at a systemic level.

EU Emissions Trading System (ETS)

The main tool until now has been the European Emission Trading System (ETS). Today, it covers 45% of all emissions in the EU, including power and heat generation, energy-intensive industry (oil refineries, steel works and iron, aluminium, lime, glass ceramics, pulp, paper, cardboard, acids and bulk organic chemicals production). The system is in its third phase until the end of 2020 and enters the fourth phase in 2021. The latter have been revised in 2018 to fit the Paris agreement. EU's ETS is still the largest in the world and it will probably continue to grow to new sectors. The Phase IV starts 2021 and the target is a 43% emission cut in the areas covered by the EU ETS.

The EU ETS's goal is to reduce emissions in the most effective manner, which in this case refers to the cheapest solution. An emitter can choose to either buy emission permits from the ETS or invest in emission reduction technology. In this way, the cheapest reduction possibilities get implemented first. The literature review by Teixidó, et al. (2019) concludes that companies often implement already existing technology instead of investing in R&D. The latter has a higher risk and is more time consuming. However, both, innovation, and adoption, are needed to majorly cut emissions. Two other important parts of ETS are its stringency and predictability. The first directly effects the size of emission cuts and the second on companies' willingness to invest in new technology. The same paper by Teixidó, et al. (2019) states literature in general to support the hypothesis that more stringent emission caps give more economic incentives.

The study examines empirical literature to study the EU ETS. Unfortunately, none of the literature covers Phase III. However, the paper presents interesting findings on the effect of EU ETS on innovations. The guess is that the effect of EU ETS is stronger today than ever before with rising emission prices and stronger rules for both Phase III and IV compared to the previous Phase I and II. On the contrary to the literature review,

the paper concludes innovation having a larger penetration to the market due to the EU ETS. This finding has however been criticised earlier. In the case of adoption of low-carbon technology, the paper suggests only low effect. In addition, the free allocation of permits in Phase I and II cut the possible emission cuts, because companies could not estimate the opportunity cost of using the allocations compared to the real cost of allowances on the market. Another example of a lost emission cut was in the power sector, where free allocations were distributed based on the emission and not output. Therefore, gas and coal, that can be seen as close fuel substitutes, were not treated based on their emissions. However, free allocations decreased risks for carbon leakage. The paper points at succeeding in the purposes it was created for.

Finland

This chapter narrows the scope down to Finland and looks at individual examples of sector integration, in addition to Finnish national environmental legislation. The latter builds on EU goals, but the ruling Finnish government has a more ambitious goal. The sitting Finnish Government has set one of the most ambitious carbon-neutrality goals in the world. The aim is to be carbon-neutral by 2035 and carbon-negative quickly after. Finland will do their share to limit global temperature increase to 1.5 °C. The sitting government also requires EU to tighten their emission reduction for 2030 to at least 55% (Valtioneuvosto, 2019).

Large changes are required to reach the goals. The latest step was the introduction of low carbon roadmaps for all larger industries, which then also smaller industries followed. They were planned by the industries themselves, but simultaneously showed commitment to the ambitious goal. The roadmaps will start the work towards a carbon-neutral society. All major industries have, in cooperation between organisations and companies, constructed low-carbon roadmaps. The goal is to get an understanding of the scale and cost of the transition. Also, the process gives Finland opportunities for export (Ministry of Economic Affairs and Employment of Finland, n.d.). The general release-date for these roadmaps were on the 9th of June 2020. The roadmaps will be used as a tool to plan favourable legislation, allocate research funding, prevent overlapping distribution of resources and to encourage international growth (Ministry of Economic Affairs and Employment of Finland, n.d.). The work initiated by the Finnish Government was influenced by similar work in United Kingdom and Sweden (Ministry of Economic Affairs and Employment of Finland, n.d.).

Finland is often seen as a forerunner in sustainability and low-carbon topics. For example, emissions from electricity production has fallen remarkably, coal will be phased-out of the system totally by 2029 and the share of renewables still increases. The district heating networks around the country allows centralised options and for example, the use of excess heat on a wider scale. However, the gas grid covers only a small area in the southern parts of the country. A study by a student team made for Finnish Energy (Kroyan, et al., 2019) pointed out that the carbon-neutrality goal is possible, but further legislation and regulations are needed, especially transport impose a problem. Also, the roadmaps gave the picture that the industries think a carbon-neutral Finland is possible by 2035. The scenario will remarkably increase the use of electricity, but simultaneously the possibilities for demand response increase. These possibilities should be exploited widely to balance the energy system.

The previous government (2015-2019) commissioned a smart grid working group with the aim to create a smart grid vision. The constructed report is already somewhat outdated (from year 2018) but gives some insight to the possibilities with smart grid. In addition, the report has put the customer in the centre, which often leads to higher acceptance.

The building of solar power in Finland increases rapidly and it is forecasted to continue (Talouselämä, 2020). The article states that growth has been at around 50% yearly and prices have fallen 10% from 2019. The solar power capacity in the national network was around 198 MW at the end of the year with some additional power in stand-alone networks at cottages. However, compared to Sweden, Finland is three years behind in capacity. One large player is Helen, who entered the solar power market a couple of years ago. Helen's solar power markets were studied in a student project (2020) at Aalto during the past spring. the goal was to

suggest innovative business models to increase its market share. The exact results were not published, but the representatives were satisfied with the results. Therefore, we can expect Helen launching new solutions related to solar power and as a big player, Helen's moves do have an impact. Already, Helen offers virtual batteries for solar power owners (Helen, 2020).

In Finland, gas is not as important as in Central Europe. The gas grid covers only parts of Southern and Eastern Finland. However, the gas market was opened for competition in the beginning of 2020. The role of gas will increase as the government aims for carbon-neutrality in 2035. Especially biogas will have a large role in decreasing the emissions from transport. In addition, the government will make a biogas program and implement monetary incentives for biogas production. This includes clarifying licensing and selling of biogas. The production is part of circular economy, which will be advanced.

However, the interest in hydrogen in the EU has grown rapidly since the last EU elections. In the beginning of July 2020, EU released a hydrogen strategy and the Covid-19 recovery plan includes funds for hydrogen production and the building of a market. Unfortunately, the interest in hydrogen has reached Finland later. This can lead to missing out on investment opportunities. Fortunately, Finland also has some developments going on. For example, VTT is developing a transferable electrolyte-fuel cell with an electrolyte efficiency of up to 80-90% (Promaint, 2019).

In transport, Finland has committed to cut emissions by 50% by 2030. The success of this particular goal has been doubted often, but some optimism is present in the field. Digitalisation offers large possibilities to cut driving with empty trucks with optimised routes (Keskipojanmaa, 2020). Only after that comes training and biogas.

Cooperation between industry and universities in Finland are strong. Many students participate in project courses with projects for companies. These give opportunities for outside the box thinking and new ideas. For example, Helen and Aalto University students investigated solar power markets. The results allow Helen to grow its solar power business.

Future Enablers

As already mentioned, The Green Deal leads the development work for the sitting EU Commission. It gives the starting point for the changes in the EU. However, the paper gives no implementable actions, they will come later. The action points are collected into the Annex of The Green Deal (European Commission, 2019). The actions are divided into ten areas (European Commission, 2019), with the most important for the energy sector being "Climate ambition" and "Clean, affordable and secure energy". However, all eight others do discuss energy, climate or sustainability on some level, which are important to reach net-zero on a larger scale and also in the energy sector. For example, the concept of circular economy is important to cut emissions in the energy sector too.

Now, hydrogen is heavily pushed as the missing piece in the puzzle to carbon-neutrality on the European continent. However, the market is mostly missing, as hydrogen only stands for around 2% of the primary energy usage in the EU today. The fuel has to be pushed from a marginal energy source to a major player in a relatively short time. In the start, all sorts of hydrogen are accepted, starting from grey continuing to blue with CCS. However, the end goal is green hydrogen, made entirely from renewable electricity. The features favouring hydrogen are the possibility to store the fuel for a longer time, compared to electricity especially, and its use its emissions are close to zero. However, the way to a large-scale production and demand of green hydrogen is long and includes many ifs.

Simultaneously as the understanding of climate change and the importance of action increase, a load minority stands against change. They are scared that cars will be prohibited and that someone else is responsible. Changes will always face criticism, but it is important to communicate facts and be transparent. However, the criticism should not be given more space or climate change mitigation acts could be cancelled.

Energy access is taken for granted and therefore, energy companies must prioritise security and ensure supply during state of emergencies. The ongoing covid-19 pandemic have showed the European energy system is resilient to this kind of shocks.

How is Sector-integration visible for final costumers?

The Green Deal states that effective carbon pricing will encourage changes in consumer and business behaviour, as well as investments (European Commission, 2019, p. 5). The goal is to build policies complementing each other and together pushing towards reduced emissions. Simultaneously, energy prices should stay affordable through full integration, interconnection and digitalisation (European Commission, 2019, p. 6). In addition, consumers should be involved and benefit from the transition, which includes preventing energy poverty. For example, financing schemes could help with energy renovation in households leading to decreased energy bills and consumption. Overall, The Green Deal aims for increased life quality for consumers in energy, food, and other health questions.

One part of The Green Deal is EU's strategy for Energy System Integration. It discusses energy related questions in further detail and looks further on the benefits for consumers. One possibility of system integration is minimized energy costs in a climate neutral system, which have for some time increased due to monetary incentives for renewable energy. In addition, it increases the possibilities for consumers to participate in the energy market with, for example, a multi-directional system supplying energy. Furthermore, consumers should be placed in the centre by making information available on how to support an integrated energy system.

Further building on this, Eurelectric (2020) assembled 15 pledges to customers with the objective to activate and involve the customers in the European electricity market. They want to involve all customers, from the active to the passive ones, in the transition and show that everyone can benefit from carbon neutral solutions and especially energy efficiency, renewables and e-mobility. Also, this document concentrates on a healthier living environment and new, interesting services. However, earlier it has been difficult to get customers involved in the change already happening in the energy industry. In addition, the paper asks all stakeholders to get involved, because otherwise a change is not possible. The problem seems to be mostly in communications and getting the message out to the citizens, because the outcome will favour everyone in the end. However, no change is possible without everyone's involvement.

Concentrating on Finland, Finnish Energy made a similar paper calling for the customers era in the energy sector. The paper concentrates on the effect of two megatrends, urbanisation and climate change, but also digitalisation, international competition, increase of renewable energy sources and the strengthening of customer roles, on the world and their connection to the energy sector. The interesting part is that customers wishes, and needs directs the industry. Customers' increased influence will change traditional business models and create opportunities for companies in the Finnish market. Overall, this paper wider discusses the disruption in the energy industry but lifts the customer into the centre. It understands that lifestyles get more diverse, households get more involved in the energy markets and that Finland becomes more of a service economy. Also, the goal is to keep Finland as a forerunner in energy sector.

The direction seems to be the same both in the EU and Finland. The households, apartments and consumers have to be integrated into the energy system and get them to join the energy transition. However, this requires automation and seamless functioning. The resident should not need to worry about energy issues if they so wish. Things will change, but the message should be that the change is for the better, at least this is the tone through The Green Deal, Energy System Integration Strategy, Eurelectric's 15 pledges and Finnish Energy's "Customers set to benefit from the new era in the energy sector". On the other hand, it would be difficult to get customers on board a change toward the worse.

One of the most active consumers will also produce energy to the networks for others to use. These consumers, often called prosumers, will use the possibilities of the multi-directional networks discussed in the EU's Energy System Integration strategy. However, the word prosumers is not mentioned in the strategy.

Another upcoming topic is energy collectives and their own production. The related EU directives are new, and they are first new entering the Finnish market. In Finland, the possibility to share electricity between apartments from a shared investment in an apartment building will come available to some in 2021 depending on the DSO and for all by close thereafter. However, actual implementation may take past that date, as the decision have to be made together with all the residents in an apartment building (Hiilineutraali Suomi, 2020).

Discussion

The Energy System Integration Strategy was, in general, openly accepted throughout the energy sector. It seems to be awaited and the position papers were mostly optimistic. However, details are missing, and these discussions can become heated. For example, the comment by EUDCA highlight the unawareness of the particular field. According to the comment, public discussion concentrates on the large energy usage, but forgets data centres importance for digitalisation. This may be applicable to other fields to. For example, the strategy discusses renewables, but does not include other low-carbon sources or mention the problems with biomass. This refers mainly to the second pillar in the strategy, which otherwise quite broadly includes different energy sources, taxation and electrification.

The third pillar concentrates on low-carbon and renewable fuels, especially hydrogen. Unfortunately, the technology is still inefficient, expensive and lacks trust among citizens and politicians. In addition, the hydrogen market is mostly inexistent in Europe. The development has to start from zero and grow rapidly. In Finland, gas is only in marginal use, but the discussion has gotten livelier during the past half a year. Only time will tell how the hydrogen market will grow. At least the hype is real and large investments are planned.

The fourth pillar mentions double grid charges, which is not a totally black and white topic. This refers to, for example, the use of batteries in the electricity grid. Now, grid charges are applied for both charging and discharging. This is seen as problematic, because it effects the competitiveness of battery storage. However, it is also a question of who should pay for the use of grids. As it is now, the costs come from use, independent of the directions of the electricity. If the said double grid charges are removed, then the expenses are just moved to someone else. Both solutions have their down- and upsides and will probably be further discussed before a decision is made.

Overall, sector-integration is a complex whole and considering all detailed wishes will be difficult. The best option would probably be to implement market-based and technology neutral regulation. The wishes of EUDCA point in this direction. It seems that listening to energy users will grow in importance and also, understanding the needs of new players.

Finland aims for carbon-neutrality by 2035. At the moment, the progress is mostly planning and discussions with the first step being announced in the beginning of June 2020 in the form of low-carbon roadmaps. The process has aimed at being aligned and the overall impression of the roadmaps is that the 2035 carbon-neutrality goal is achievable. Finland has also previously been a sustainable forerunner and the roadmaps give further opportunities to upkeep the position. This can already be seen in many pilot projects, student cooperation projects and different services.

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Appendix 1

Key Actions copied from European Commission Energy System Integration strategy.

3.1. A more circular energy system, with 'energy-efficiency-first' at its core	
To better apply the energy-efficiency-first principle	
Issue guidance to Member States on how to make the energy-efficiency-first principle operational across the energy system when implementing EU and national legislation	by 2021
Further promote the energy-efficiency-first principle in all upcoming relevant methodologies (e.g. in the context of the European resource adequacy assessment) and legislative revisions (e.g. of the TEN-E Regulation ²⁰)	
Review the Primary Energy Factor, in order to fully recognise energy efficiency savings via renewable electricity and heat, as part of the review of the Energy Efficiency Directive	June 2021
To build a more circular energy system	
Facilitate the reuse of waste heat from industrial sites and data centres, through strengthened requirements for connection to district heating networks, energy performance accounting and contractual frameworks, as part of the revision of the Renewable Energy Directive and of the Energy Efficiency Directive	June 2021
Incentivise the mobilisation of biological waste and residues from agriculture, food and forestry sectors and support capacity-building for rural circular energy communities through the new Common Agriculture Policy, Structural Funds and the new LIFE programme	from 2021 onwards
3.2. Accelerating the electrification of energy demand, building on a largely renewables-based power system	
To ensure continued growth in the supply of renewable electricity	
Through the Offshore Renewable Strategy and follow-up regulatory and financing actions, ensure the cost-effective planning and deployment of offshore renewable electricity, taking into account the potential for on-site or nearby hydrogen production, and strengthen EU's industrial leadership in offshore technologies	2020
Explore establishing minimum mandatory green public procurement (GPP) criteria and targets in relation to renewable electricity, possibly as part of the revision of the Renewable Energy Directive, supported by capacity building financing under the LIFE programme	RED June 2021
Tackle remaining barriers to a high level of renewable electricity supply that matches the expected growth in demand in end-use sectors, including through the review of the Renewable Energy Directive	June 2021
To further accelerate the electrification of energy consumption	
As part of the Renovation Wave initiative, promote the further electrification of buildings' heating (in particular through heat pumps), the deployment of on-	from 2020 onwards

buildings renewable energy, and the roll-out of electric vehicle charging points, using all available EU funding, including the Cohesion Fund and InvestEU.	
Develop more specific measures for the use of renewable electricity in transport, as well as for heating and cooling in buildings and industry, in particular through the revision of the Renewable Energy Directive, and building on its sectoral targets	June 2021
Finance pilot projects for the electrification of low-temperature process heat in industrial sectors through Horizon Europe and the Innovation Fund	by 2021
Assess options to support the further decarbonisation of industrial processes, including through electrification and energy efficiency, in the revision of the Industrial Emissions Directive	2021
Propose to revise CO ₂ emission standards for cars and vans to ensure a clear pathway from 2025 onwards towards zero-emission mobility	June 2021
To accelerate the roll-out of electric vehicle infrastructure and ensure the integration of new loads	
Support the roll-out of 1 million charging points by 2025, using available EU funding, including the Cohesion Fund, InvestEU and Connecting Europe Facility funding, and communicate regularly on the funding opportunities and regulatory environment to roll out a charging infrastructure network	from 2020 onwards
Use the upcoming revision of the Alternative Fuels Infrastructure Directive to accelerate the roll-out of the alternative fuels infrastructure, including for electric vehicles, strengthen interoperability requirements, ensure adequate customer information, cross-border usability of charging infrastructure, and the efficient integration of electric vehicles in the electricity system	by 2021
Take up corresponding requirements for charging and refuelling infrastructure in the revision of the Regulation for the Trans-European Transport network (TEN-T) (by 2021) and explore greater synergies through the revision of the TEN-E Regulation in view of possible energy network related support for cross border high capacity recharging as well as possibly hydrogen refuelling infrastructure	by 2020
Develop a Network Code on Demand Side Flexibility ³⁵ to unlock the potential of electric vehicles, heat pumps and other electricity consumption to contribute to the flexibility of the energy system	starting end-2021
3.3. Promote renewable and low-carbon fuels, including hydrogen, for hard-to-decarbonise sectors	
Promote renewable and low-carbon fuels, including hydrogen, for hard-to-decarbonise sectors	
Propose a comprehensive terminology for all renewable and low-carbon fuels and a European system of certification of such fuels, based notably on full life cycle greenhouse gas emission savings and sustainability criteria, building on existing provisions including in the Renewable Energy Directive	June 2021
Consider additional measures to support renewable and low-carbon fuels, possibly through minimum shares or quotas in specific end-use sectors (including aviation and maritime), through the revision of the Renewable Energy Directive and building on its sectoral targets (June 2021), complemented, where appropriate, by additional measures assessed under the REFUEL Aviation and FUEL Maritime	

initiatives (2020). The support regime for hydrogen will be more targeted, allowing shares or quota only for renewable hydrogen.	
Promote the financing of flagship projects of integrated, carbon-neutral industrial clusters producing and consuming renewable and low-carbon fuels, through Horizon Europe, InvestEU and LIFE programmes and the European Regional Development Fund	from 2021
Stimulate first-of-a-kind production of fertilisers from renewable hydrogen through Horizon Europe	from 2021
Demonstrate and scale-up the capture of carbon for its use in the production of synthetic fuels, possibly through the Innovation Fund	from 2021
Develop a regulatory framework for the certification of carbon removals based on robust and transparent carbon accounting to monitor and verify the authenticity of carbon removals	by 2023
3.4. Making energy markets fit for decarbonisation and distributed resources	
To promote a level-playing field across all energy carriers	
Issue guidance to Member States to address the high charges and levies borne by electricity and to ensure the consistency of non-energy price components across energy carriers	by 2021
Align the taxation of energy products and electricity with EU environment and climate policies, and ensure a harmonised taxation of both storage and hydrogen production, avoiding double taxation, through the revision of the Energy Taxation Directive	
Provide more consistent carbon price signals across energy sectors and Member States, including through a possible proposal for the extension of the ETS to new sectors	by June 2021
Further work towards the phasing out of direct fossil fuel subsidies, including in the context of review of the State aid framework and the revision of the Energy Taxation Directive	from 2021 onwards
Ensure that the revision of the State aid framework supports cost-effective decarbonisation of the economy where public support remains necessary	by 2021
To adapt the gas regulatory framework	
Review the legislative framework to design a competitive decarbonised gas market, fit for renewable gases, including to empower gas customers with enhanced information and rights	by 2021
To improve customer information	
In the context of the Climate Pact, launch a consumer information campaign on energy customer rights	by 2021

Improve information to customers on the sustainability of industrial products (in particular steel, cement and chemicals) as part of the sustainable product policy initiative, and, as appropriate, through complementary legislative proposals	by 2022
3.5. A more integrated energy infrastructure	
Ensure that the revisions of the TEN-E and TEN-T regulations (in 2020 and 2021, respectively) fully support a more integrated energy system, including through greater synergies between the energy and transport infrastructure, as well as the need to achieve the 15% electricity interconnection target for 2030.	
Review the scope and governance of the TYNDP to ensure full consistency with the EU's decarbonisation objectives and cross-sectoral infrastructure planning as part of the revision of the TEN-E Regulation (2020) and other relevant legislation	2021
Accelerate investment in smart, highly-efficient, renewables-based district heating and cooling networks, if appropriate by proposing stronger obligations through the revision of the Renewable Energy Directive and the Energy Efficiency Directive (June 2021), and the financing of flagship projects.	
3.6. A digitalised energy system and a supportive innovation framework	
Adopt a Digitalisation of Energy Action plan to develop a competitive market for digital energy services that ensures data privacy and sovereignty and supports investment in digital energy infrastructure	2021
Develop a Network Code on cybersecurity in electricity ⁵⁶ with sector-specific rules to increase the resilience and cybersecurity aspects of cross-border electricity flows, common minimum requirements, planning, monitoring, reporting and crisis management	by end 2021
Adopt the implementing acts on interoperability requirements and transparent procedures for access to data within the EU	first on in 2021
Publish a new impact-oriented clean energy research and innovation outlook for the EU to ensure research and innovation supports energy system integration	by end 2020