Response to European Commission consultation on EU strategy for energy sector integration

15 May 2020

Summary

- An enhanced sector integration is required to ensure the beneficial electrification of end-uses and the deployment of renewable power and distributed energy resources, which are prerequisites to enable a climate-neutral future (Question 1). Several barriers currently prevent this from happening at the speed needed (Question 2).
- Guiding principles are needed to enable a smart sector integration. First, integrated planning should be operationalised across all dimensions. Second, the efficiency first principle should be embedded to assess the different options (Question 2). Third, the distributional impacts — who pays and who benefits — should be assessed and steps taken to ensure that low-income consumers do not get left behind.
- The role of electrification to drive decarbonisation in the transport and building sectors should be a primary focus of the sector integration strategy given the synergies between decarbonising these two sectors and decarbonising the electricity sector, with the associated energy efficiency gains (Question 3.1).
- The focus should be on decarbonising gas end-uses, not on decarbonising gas. Valuable resources such as hydrogen should not in be used for applications that can be electrified at lower cost (Questions 3.2 and 3.4).
- Energy markets should provide the right incentives for a smart sector integration, including by recognising the value of distributed energy resources, giving the right price signals to consumers and the right incentives to network companies (Question 3.5).
- Digitalisation should help maximise the use of infrastructure whilst enabling the consideration of distributed energy resources (Question 3.6).
- The Horizon 2020 Enefirst project highlights worldwide best practices that are relevant for the smart sector integration strategy (Question 5). Several initiatives are also described in Annex I.
- Measures fostering a smart sector integration should comply with or enable the application of the guiding principles (cf. Question 1). They should enable further take-up of useful technologies, a modernisation of energy market rules as well as directing investments into the right infrastructure (Question 6).

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RAP welcomes the opportunity to provide input to the upcoming EU strategy on energy sector integration.

Question 1. What would be the main features of a truly integrated energy system to enable a climate neutral future? Where do you see benefits or synergies? Where do you see the biggest energy efficiency and cost-efficiency potential through system integration?

An increasingly integrated energy system is required to enable a climate-future. The following principles should be applied to maximise environmental, social and economic benefits and enable a smart sector integration:

- Integrated planning across all dimensions.

Sector integration is the optimisation of the energy system across various dimensions:
1. Carriers and related infrastructures.
2. Supply, demand and storage.
3. Centralisation levels/scales.

Reaching carbon neutrality will require fundamental changes in our energy system, starting with the need to tap all the cost-effective energy savings potential to keep the costs of the energy transition down. As an increasing amount of electricity will be generated from variable and decentralised renewable sources, demand or customer-side resources will also need to contribute to a stable electric grid by providing flexibility. Increased resource flexibility is essential to maintain reliable electric service and to minimise the need for redundant, costly generation assets.

Building synergies among renewable energy, demand response and energy efficiency across all of the dimensions described above requires integrated planning.

- Assessment of options using the efficiency first principle.

Sector integration should aim to achieve decarbonisation at least cost from a societal point of view. This means that the environmental, social and economic aspects need to be considered. Furthermore, a long-term planning horizon must be defined to assess the different options and avoid lock-in into certain technologies or pathways. The energy efficiency first principle needs to be reiterated and further operationalised to serve this purpose.[1]

The sector integration strategy would be an appropriate place for the Commission to highlight these two guiding principles and engage in a dialogue with the Parliament, Member States and stakeholders on how these principles shall be further enshrined and operationalized in the EU acquis.

[1] Research by the ENEFIRST H2020 project provides detailed thinking of how this can be achieved (https://enefirst.eu/).

- Ensuring the poorest can benefit

Sector integration should pursue outcomes, particularly in buildings and transport sectors, that improve the situations of low-income communities and households and alleviate energy poverty. Significant barriers prevent low-income households from participating in mainstream energy efficiency, renewable energy and fuel-switching initiatives. Their participation therefore needs to be specifically targeted and enabled through policies focussed on specific consumers and communities (e.g., rural communities). The benefits of decarbonisation should be brought forward for these groups to balance rising costs and ensure that low-income groups are not left reliant on incumbent infrastructure and high-carbon fuels that will rise in cost as other consumer groups move to decarbonised sources.[2]

Question 2. What are the main barriers to energy system integration that would require to be addressed in your view?

Smart energy system integration requires electrification of end-uses and further deployment of distributed energy resources. The main barriers to these developments are largely regulatory and institutional — not technological. They could be described in the sector integration strategy, together with potential solutions on how to overcome them. They include, among others:

- Lack of level-playing field between energy carriers.

Achieving our EU 2030 targets and climate neutrality by 2050 will require significant electrification of energy uses. In many countries, it is, however, much more expensive to use electricity compared to oil and gas. In Europe, most electricity generation is covered by the EU Emissions Trading System (ETS), whereas other heating fuels are not. Also, Member States attribute the majority of levy-funded climate policy costs to electricity, an approach that does not allocate costs fairly.[3] For example, recent analysis in the UK has highlighted that current policy structures may exacerbate the cost differential between electricity and gas, and this can be a barrier to heat decarbonisation. Specifically, electricity in the UK is subject to a carbon tax and levies whilst gas is not.[4]

This is no longer justified, as in many EU Member States carbon emissions from electricity are now lower than oil and gas. If unaddressed, the uneven sharing of the costs of the clean energy transition between different fuels will result in disincentives for accelerated electrification.

Potential solution: The sector integration strategy should review the current imbalances between the different fuels regarding levies and taxes and propose a way forward,

[2] Sunderland, L., Jahn. A., Hogan, M., Rosenow, J., & Cowart, R. (2020). *Equity in the energy transition*. Forthcoming on www.raponline.org

[3] Grave, K., Breitschopf, B., Ordonez, J., Wachsmuth, J., Boeve, S., Smith, M., … Schleich, J. (2016). *Prices and costs of EU energy.* Retrieved from https://ec.europa.eu/energy/sites/ener/files/documents/report_ecofys2016.pdf

[4] Barnes, J., & Mothilal, S. (2019, January). The economics of heat pumps and the (un)intended consequences of government policy. *Energy Policy,* 111198. Retrieved from https://doi.org/10.1016/j.enpol.2019.111198

including a direction of travel for the review of the ETS and the Energy Taxation Directive.

- Lack of appropriate incentives for network operators.

The need to accommodate increasing amounts of variable renewable energy resources is posing challenges to grid operation and development that will only intensify in the years ahead. In most Member States, power sector regulation does not incentivise network operators enough to play a pivotal role in exploiting these opportunities and facilitating a cost-effective clean energy transition.

- Lack of access to energy markets by renewable energy and aggregators.

Energy markets are typically designed for centralised, dispatchable fossil fuel plants. Too often, market rules limit the development of distributed energy resources, including demand-side response, and integration of variable renewable energy resources, which may require aggregation to participate in markets and an adjusted product design.

Too often, market access is hampered by specific market rules making it difficult for aggregators to participate. Distributed energy resources tend to be too small to participate directly in the organised wholesale electric markets on a stand-alone basis. First, they often do not meet the minimum size requirements to participate in these markets under existing participation modes. Second, they may have difficulty satisfying all of the operational performance requirements of the various participation models due to their small size. Third, the product standards are designed for dispatchable resources and need to be adjusted to fluctuating generation, by time frame of commitment and tenders before the delivery period.

- Lack of smart readiness of technologies deployed.

<u>In the transport sector</u>:
The lack of smart technology roll-out can prevent smart charging and cost-efficient grid integration of electric vehicles (EVs). Two examples:

1. Charging infrastructure is not always equipped with sufficiently 'intelligent' technology that enables users to subscribe to dynamic tariffs and increase synergies between the electricity and transport sectors. This means that EVs are connected to chargers that do not have any measurement or communication capabilities. This also slows down the deployment of automation technology to support smart charging and to help consumers achieve savings.
2. The rollout of smart meters is still far behind in many EU Member States. Smart meters in households would also enable electricity users to subscribe to more dynamic tariffs and charge EVs grid-optimally and integrate them on a single-household meter. Through regulation, EV chargers can be required to have smart functionality. This is already the case in some EU Member States.[5]

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[5] Hildermeier, J., Kolokathis, C., Rosenow, J., Hogan, M., Wiese C., & Jahn, A. (2019). *Start with smart: Promising practices for integrating electric vehicles into the grid.* Retrieved from https://www.raponline.org/knowledge-center/start-with-smart-promising-practices-integrating-electric-vehicles-grid/

In the building sector:
In the past, most attention has been paid to flexibility in power systems, with limited attention given to heat demand. With increasing integration of the power and heat sectors, heat flexibility becomes highly relevant. Equipment is, however, often installed without paying attention to this new opportunity to provide flexibility services. A key technology for decarbonisation of buildings will be heat pumps. Already today, heat pumps possess the ability to be controlled and to follow wholesale market energy prices, time-of-use tariffs, carbon emission intensities, the prevalence of renewables or a combination of these factors. However, this 'smartness' is not standardised across Europe and it is currently down to the manufacturers of heat pumps to decide whether or not to build in smart controls.[6]

- Network tariffs providing wrong price signal to consumers.

In Europe, most consumers are paying increasingly rising fixed charges as well as flat electricity tariffs.[7] Both promote consumption at times of stress on the system and overconsumption generally, resulting in increased costs for all by driving excessive investment in underutilised grid infrastructure and supply resources.[8] Given the need to decarbonise the transport and heat sectors in large part through electrification, fixed charges will exacerbate the problem of underutilised infrastructures and higher costs for the energy transition. Dynamic pricing for residential customers based on wholesale market prices has been addressed by the Clean Energy Package, but further shifts of network costs to fixed charges will lead to overbuilding distribution infrastructure and, in doing so, will create a significant hurdle for the beneficial electrification of the heat and transport sectors.

Question 3.1. More specifically, how could electricity drive increased decarbonisation in other sectors? In which other sectors do you see a key role for electricity use? What role should electrification play in the integrated energy system?

The role of electrification to drive decarbonisation in the transport and the building sectors should be the primary focus of the sector integration strategy, given the

[6] Delta Energy & Environment. (2014). *IEA HPP Annex 42: Heat Pumps in smart grids; Review of smart ready products, United Kingdom*. Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/341743/Delta-ee_Smart_Ready_Heat_Pumps_in_UK_22_Jan_14_FINAL.pdf
[7] Network charges are fees paid by consumers to cover the costs for power lines and other network assets and services. They form a significant part of consumers' bills. These costs have been increasing and are expected to continue increasing, especially at the distribution network level, as they are expanded to accommodate new distributed activities, such as electric vehicle charging and distributed generation, and are modernised to make them smarter. Network charges are commonly split into fixed (standby, demand or capacity fees) and volumetric (or variable) components.
[8] Fixed charges take the power of choice out of consumers' hands and are contrary to the EU vision of broad deployment of energy efficiency, demand response and distributed generation. They shift costs from high-use to low-use consumers. Flat volumetric tariffs incentivise energy efficiency but fall short on the required flexibility.

synergies between decarbonising these two sectors and decarbonising the electricity sector with the associated efficiency gains. More specifically:

- In the transport sector.

Electrification of transport can leverage the potential for complementarity between the needs of electricity decarbonisation and the urgent need for reduction of transport emissions (CO_2 and air pollutants). Electricity grids are looking for ways to make productive use of large volumes of low-cost, zero-carbon energy that will be available at times when it may not have been needed to meet traditional demands for electricity. One such use is the shifting of flexible loads from times when variable production or grid capacity is scarce. At the same time, EVs represent large, inherently flexible loads, the growth of which would benefit greatly from opportunities to lower operating costs (to offset higher upfront costs) and from opportunities to minimise the need to build and recover the costs of grid infrastructure.

For road transport, direct electrification through battery electric vehicles is the most energy efficient and promising market development. Already today, for passenger cars,[9] life-cycle emissions are on average about three times lower than that of comparable petrol and diesel cars. These emission reductions will grow further as the grid is increasingly decarbonised. Similar efficiency and emission-related gains can be expected from electric vans, which have great potential in short-haul and electric logistics operations. For heavy-duty vehicles in road freight, prospects are promising for battery-based systems as well as electric road systems. Globally, electric car deployment has been growing rapidly[10] over the past 10 years, with the global stock of electric passenger cars passing 5 million in 2018, an increase of 63% from the previous year. Europe accounted for 24% of the global fleet.

More information and recommendations:
☐ Hildermeier, J., Kolokathis, C., Rosenow, J., Hogan, M., Wiese C., & Jahn, A. (2019). *Start with Smart: Promising practices for integrating electric vehicles into the grid*. Regulatory Assistance Project.

- In the building sector.

A key element in decarbonising European buildings is expected to be increasing the share of electricity used for heat with electricity as part of decarbonisation. This is reflected in several European Commission reports,[11] EU-funded analysis,[12] research

[9] T&E. (2020). *How clean are electric cars? T&E's analysis of electric car lifecycle CO_2 emissions.* Retrieved from https://www.transportenvironment.org/sites/te/files/downloads/T%26E%E2%80%99s%20EV%20life%20cycle%20analysis%20LCA.pdf
[10] IEA. (2019). *Global EV Outlook 2019*. Retrieved from https://www.iea.org/reports/global-ev-outlook-2019
[11] For example, Kavvadias, K., Navarro, J., and Thomassen, G. (2019). *Decarbonising the EU heating sector: Integration of the power and heating sector*. EUR 29772 EN, Publications Office of the European Union, Luxembourg. Retrieved from https://ec.europa.eu/jrc/en/publication/decarbonising-eu-heating-sector-integration-power-and-heating-sector
[12] Heat Roadmap Europe. (2019). *The Legacy of Heat Roadmap Europe 4*. Retrieved from https://heatroadmap.eu/wp-content/uploads/2019/02/HRE_Final-Brochure_web.pdf

commissioned by the European Climate Foundation[13] and analysis at Member State level (e.g., Germany,[14] the Netherlands[15] and the UK).[16]

As shown below in Figure 1, the emission intensity of electricity across Europe and in relevant Northern EU countries has reduced significantly over the past two decades, and with further renewable deployment it is likely to reduce further.

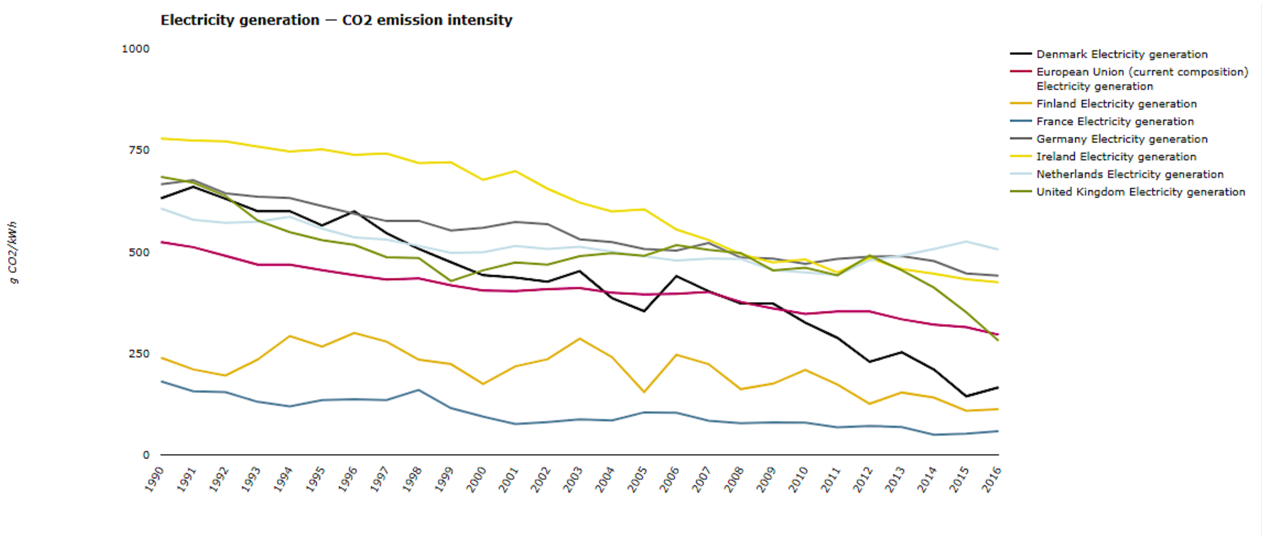

Figure 1: Electricity generation and CO2 emission intensity, European Environment Agency

Heat pumps, through their conversion factor or coefficient of performance[17], can effectively reduce the carbon intensity of the electricity they use by a factor of the coefficient of performance, which typically averages around three. Heat pumps can extract waste heat, heat from water sources or ambient heat from the ground or air. Large-scale heat pumps can also integrate very well with district heating systems and have been part of district heating for many years in the Nordic countries.

Heat pumps are, however, also not without issues: these include higher upfront costs than gas boilers and the requirement for heating systems and buildings suitable for lower flow temperatures than those normally associated with gas boilers. Heat electrification also introduces an array of wider energy system issues. These issues, and how to counteract them, are the focus of a recent report published by RAP.

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[13] Element Energy and Cambridge Econometrics. (2019). *Towards fossil-free energy in 2050.* Study conducted for and commissioned by the European Climate Foundation. Retrieved from https://europeanclimate.org/resources/fossil-free-energy-systems-in-europe-are-feasible-by-2050/

[14] ifeu, Fraunhofer IEE, and Consentec. (2018). *Building sector efficiency: A crucial component of the energy transition; A study commissioned by Agora Energiewende.* Retrieved from https://www.agora-energiewende.de/fileadmin2/Projekte/2017/Heat_System_Benefit/163_Building-Sector-Efficiency_EN_WEB.pdf

[15] Ministry of Economic Affairs. (2015). *The Netherlands Heat Vision.*

[16] Strbac, G., Pudjianto, D., Sansom, R., Djapic, P., Ameli, H., Shah, N., & Hawkes, A. (2018). *Analysis of Alternative UK Heat Decarbonisation Pathways for the Committee on Climate Change.*

[17] Coefficient of performance is measured as a positive number reflecting the total heat output compared to electrical input. For example, a coefficient of performance of three means for each unit of electricity input, three units of heat are produced.

More information and recommendations:
☐ Rosenow, J., & Lowes, R. (2020). *Heating without the hot air: Principles for smart heat electrification.* Regulatory Assistance Project.

Key findings from this report include:

- Energy efficiency is critical for integrating heat pumps into the energy system. It reduces heat demand and thereby the investment required to decarbonise heat; it enables buildings that are electrified to act as a flexible resource; and it enables low-carbon and zero-carbon heating systems to operate at higher performance. By reducing demand for, and the associated costs of, zero-carbon heating, energy efficiency can also support a more socially equitable heat transformation.
- Using additional electric heat loads flexibly is important for integrating a growing share of renewables and mitigating avoidable increases in peak load. Luckily, electrified heat can be very flexible and can provide demand-side response functions by using the building and district heating networks as a thermal battery.
- If a larger share of heat is electrified, the emission intensity of electricity becomes increasingly important. Carbon emissions per unit of electricity consumed differs significantly over the course of a day. Electrified heat can take advantage of this by consuming electricity when there is a lot of zero-carbon electricity on the system and by avoiding peak hours, when emissions are typically the highest.

Question 3.2. What role should renewable gases play in the integrated energy system?

- Decarbonising gas versus decarbonising gas uses.

The starting point should be clarified. The discussion around renewable gas is often driven by the objective to 'decarbonise gas.' However, the goal should be to 'decarbonise gas *end-uses*.' This should be clarified in the sector integration strategy.

Decarbonising gas end-uses should be achieved through the most cost-effective approach, including the application of the efficiency first principle. In the transport and buildings sectors, a combination of efficiency, demand flexibility and electrification will be a more cost-effective mix.

- Transparent review of options is needed.

Most work suggesting renewable gases should play a major role for heating has been funded by the gas industry and was not undertaken independently.[18] Modelling by

[18] For example: Navigant. (2019). *Gas for climate: The optimal role for gas in a net zero emissions energy system.* Retrieved from https://gasforclimate2050.eu/wp-content/uploads/2020/03/Navigant-Gas-for-Climate-The-optimal-role-for-gas-in-a-net-zero-emissions-energy-system-March-2019.pdf; and Pöyry Management Consulting. (2019). *Hydrogen from natural gas: The key to deep decarbonisation.* Discussion

Cambridge Econometrics and Element Energy shows that whilst using low-carbon gases as an energy carrier does reduce the investment required in the electricity grid,[19] all scenarios (including those reliant on hydrogen) require a significant increase in electricity network capacity compared to today. This modelling also shows that whilst the scenarios relying on gases reduce the investment required in electricity networks compared to high electrification pathways, these savings are outweighed by additional gas infrastructure costs.[20]

Question 3.4. What role should hydrogen play and how could its development and deployment be supported by the EU?

Hydrogen is a premium fuel and has many wide-ranging applications. Recent work by the IEA[21] shows the breadth of competing applications, ranging from industry applications, aviation, long-distance vehicle travel and heavy-duty vehicles to power generation, to name just a few.

However, great uncertainty exists on the use of hydrogen in heating, as questions remain around production methods, transmission, its performance as a heating fuel and the cost of production. The more important question is whether a highly valuable resource such as hydrogen[22] should be used for low-grade heat provision when there are other competing uses where alternatives are more constrained.

It is also worth noting that whilst hydrogen is often presented by incumbent voices as a less disruptive approach than widespread electrification, even ignoring its uncertainty, it cannot be provided at the cost of current fossil energy sources, and it will require significant changes. Hydrogen is still likely to require substantial disruption for both consumers and industry with the requirement for hydrogen-suitable appliances, modifications to gas transportation infrastructure and rapid growth in hydrogen production facilities.[23] The costs associated with hydrogen conversion, and the associated uncertainties, mean that electrification is still regarded as a core strategy for heat decarbonisation, even in the UK, where there is a well-developed gas grid.[24]

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paper commissioned by Zukunft ERDGAS. Retrieved from https://www.poyry.com/sites/default/files/zukunft_erdgas_key_to_deep_decarbonisation_0.pdf

[19] Even if managed flexibly and with investments in energy efficiency, electrification will require significant residual network reinforcement costs.

[20] Element Energy and Cambridge Econometrics, 2019.

[21] IEA. (2019). *The Future of Hydrogen.* Paris, France: Author. Retrieved from: https://www.iea.org/reports/the-future-of-hydrogen

[22] In the future, some hydrogen may not be in this category. If it is the only viable product for electricity that is otherwise constrained off, it is arguably a form of flexibility and not necessarily a premium fuel. This is clearly not a major issue in current systems but could play a larger role in very high renewable systems.

[23] Ketsopoulou, I., Taylor, P., Watson, J., Winskel, M., Kattiritzi, M., Lowes, R., & Lockwood, M. (2019). *Disrupting the UK energy system: Causes, impacts and policy implications.* Retrieved from http://www.ukerc.ac.uk/publications/disrupting-uk-energy-system.html

[24] Committee on Climate Change. (2019). *Net Zero technical report.* Retrieved from https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-Technical-report-CCC.pdf

Comparing heat pumps and hydrogen for heat

Given that key, scalable, low-carbon heating technologies rely at least in part on renewable electricity, it is useful to compare the respective capacity requirements. Previous analysis shows that generating one unit of usable heat through different technologies requires substantially different amounts of renewable electricity.[25, 26] Limiting the number of conversions from one energy vector to another will be important to avoid wasting renewable electricity. Also, the ability to use electricity for converting ambient heat into space and hot water heat provides an option to limit the amount of electricity required.

Figure 2, compiled by the UK's Committee on Climate Change, demonstrates the differences in electricity needed to generate one unit of heat from either hydrogen or heat pumps, showing that heat pumps require significantly less electricity for generating a unit of heat.

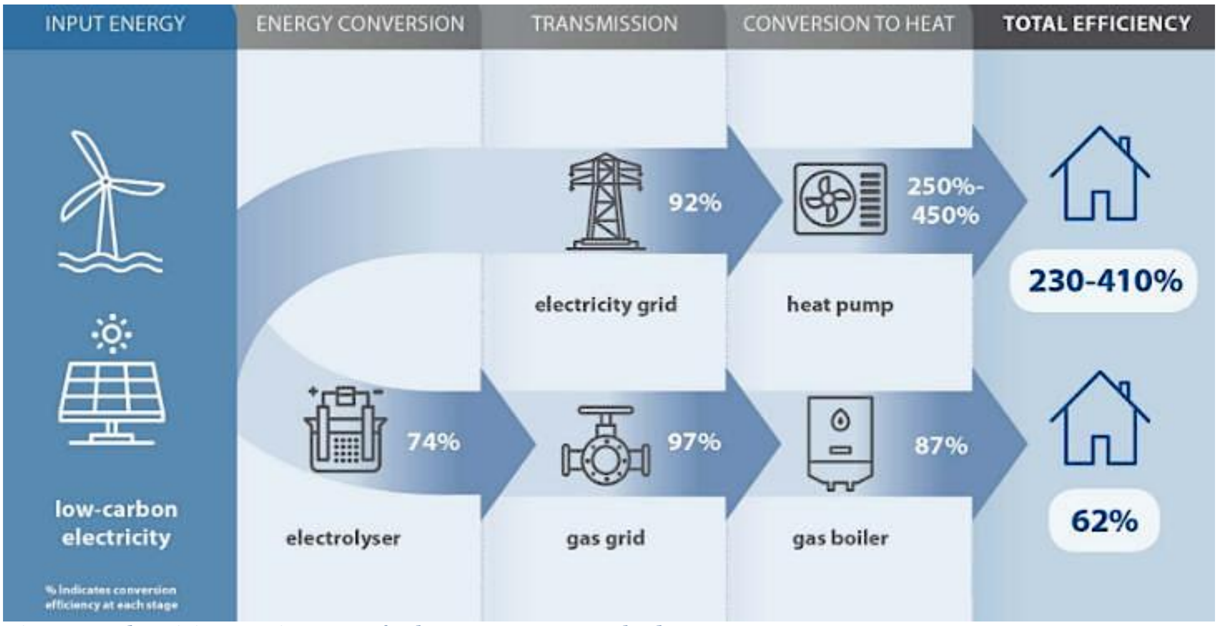

Figure 2: Electricity requirements for heat pumps versus hydrogen[27]

An important conclusion from the analysis done by the Committee on Climate Change is that 'surplus' low-carbon power is limited. Whilst there is some opportunity to utilise some surplus electricity (e.g., from renewables generating at times of low demand) for hydrogen production, their modelling shows that the quantity is likely to be small in comparison to the potential scale of hydrogen demand. Producing hydrogen in bulk from electrolysis would be much more expensive and would entail extremely challenging build rates for zero-carbon electricity generation capacity.[28]

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[25] Agora Verkehrswende and Agora Energiewende. (2018). *The future cost of electricity-based synthetic fuels.* Retrieved from https://www.agora-energiewende.de/fileadmin2/Projekte/2017/SynKost_2050/Agora_SynKost_Study_EN_WEB.pdf
[26] There are, of course, other important considerations, such as peak load capacity requirements, when comparing different technologies.
[27] Committee on U.K. Climate Change (CCC). (2018). *Hydrogen in a low carbon economy.* Retrieved from https://www.theccc.org.uk/publication/hydrogen-in-a-low-carbon-economy
[28] Committee on UK Climate Change (CCC). (2018). *Hydrogen in a low carbon economy.*

Question 3.5. How can energy markets contribute to a more integrated energy system?

Energy markets can provide the right incentives to enhance a smart sector integration by:

- Considering and prioritising demand-side resources in line with the efficiency first principle.

Demand resources are important as they widen the pool of energy system resources and allow for additional flexibility. This is particularly relevant in the context of the sector integration strategy. They are usually cheaper than many supply options (lower investment costs). Integrating resources down to the household level is especially useful to tackle local grid congestion.

The implementation of the efficiency first principle should allow for a fair comparison of supply and demand options. Indeed, policies or regulatory frameworks implementing the efficiency first principle aim explicitly at considering demand-side options as alternatives to supply-side options, thereby valuing the contributions of energy efficiency to the energy systems and, where possible, other objectives (e.g., reducing greenhouse gas emissions, improved health). While energy markets should be reformed to ensure that efficiency and demand-side resources can compete fairly with supply-side solutions, it's critical to realise that many of the benefits of efficiency are either unpriced (e.g., clean air, health benefits) or socialised on the supply side (e.g., network costs rolled into tariffs), so deliberate policies are needed to ensure that energy networks and providers invest in the least-cost mix of low-carbon resources. Better markets will help, but are not the whole answer to the sub-optimal level of investment in efficient resources we have seen in practice.

Embracing the concept of efficiency first means the recognition that:

- Demand is not fixed, and supply should not automatically be scaled up to meet it.
- Demand-side resources should be taken into account as an alternative to supply-side options before committing to investment decisions.
- Demand-side options should be chosen whenever they are more cost effective than traditional supply-side solutions, taking into account society's point of view (i.e., a broader scope of costs and benefits, compared to the end-user's point of view).
- Cost efficiency is a regulatory must.

Source: Enefirst (2020)

More information and recommendations:
☐ Enefirst. (2020). *Defining and contextualizing the efficiency first principle.*

- Recognizing the value of distributed energy resources.

To integrate distributed energy resources (DERs) efficiently and effectively, their value to the power system needs to be analysed and remunerated in a fair manner. The system value of DERs includes, for example, emission reductions (in many countries, carbon emissions have a cost associated with them as a result of emissions trading systems or carbon taxes), avoided line losses (i.e., the amount of electricity lost in transmission and distribution), local labour market support (i.e., local job creation as a result of the manufacturing, installation and maintenance of DERs), and increased tax revenues for municipalities (in case municipalities receive taxes from companies involved in DERs).

- Using flexibility from transport and heat demand for renewable energy resource integration.

The variable nature of wind and solar generation can be balanced more easily with new electrified demand in the heating and transport sector compared to existing power demand (see Question 3.1 above). The increasing electrification of transport and heat makes it easier to build additional flexibility requirements into the upcoming investment, compared to existing devices.

Allowing both electricity retailers and independent aggregators of flexibility services to compete in the market is key to providing cost-effective consumer services.

- Addressing local congestion by price signals to consumers and aggregators.

As more and more renewable energy resources will be connected to distribution networks, the networks need to be improved and extended. Local congestion will need to be addressed. However, currently wholesale market prices from large national bidding zones and fixed or annual network fees are not providing the right incentives to invest in the right solution in the right location. Well-designed bidding zones or nodal pricing plus bidirectional volumetric network fees are measures for market-based solutions to link together supply and demand more locally.

More information and recommendations:
☐ Hogan, M. (2018). *Locational Pricing in Poland: Lessons from experience.*
☐ Hogan, M., Weston, F., & Piria, R. (2018). *Power systems in the 2020s: What can Germany and the PJM region learn from each other?*

- Giving the right price signals to consumers for beneficial electrification.

Tariff design is important to give the right price signal to consumers. A smart tariff design will enable customers to optimise the use of existing infrastructure whilst limiting future system costs. To the extent additional demand can be accommodated with existing infrastructure, grid costs can be spread over a larger volume of consumption, thus reducing bills for all customers instead of driving unneeded new investment and higher costs.

Smart tariffs range from time-of-use tariffs, in which the consumer pays a different, predetermined fee for specified blocks of time based on historical usage patterns (such as a day and night tariff or a weekday and weekend tariff), to the most granular real-time-pricing, in which price is determined by actual conditions on the system from one interval to the next. In between the two, critical peak pricing sets significantly higher prices for a limited number of prenotified 'critical peak' periods.[29]

More information and recommendations:
☐ Kolokathis, C., Hogan, M., & Jahn, A. (2018). *Cleaner, smarter, cheaper: Tariff design for a smart future.* Regulatory Assistance Project.

- Giving the right incentives to network companies.

Network companies, particularly distribution system operators, will play a pivotal role in facilitating a cost-effective clean energy transition. Using performance-based regulation to link the remuneration of network companies to outcomes consistent with the clean energy transition is an effective method for motivating network companies to become active agents of this change. An outcome-based approach can provide them with incentives to support the energy transition in addition to addressing more traditional concerns, such as reliable and affordable electricity supply. It can help network companies contend with issues, including rising amounts of variable renewable energy sources and increases in prosumerism, decentralised generation and growing demand from electrification of the heating and transport sectors.

Equally important, regulation needs to ensure network companies meet consumers' needs. They will place the most value on excellent customer service, efficiency in dealing with complaints, rapid connection to the power system and high levels of network reliability and supply quality. By focusing on these outputs and requiring delivery at least cost, policymakers can protect consumers' interests in the energy transition. The key to encouraging positive performance over the long term is having clear goals, directional incentives and transparent, measurable metrics to assess progress.

More information and recommendations:
☐ Pató, Z., Baker P., & Rosenow, J., (2019). *Performance-based regulation: Aligning incentives with clean energy outcomes.* Regulatory Assistance Project.

Question 3.6. How can cost-efficient use and development of energy infrastructure and digitalisation enable an integration of the energy system?

Existing infrastructure utilisation should be maximised, whilst new infrastructure should be planned in an integrated fashion (cross vectoral) and with full consideration

[29] RAP. (2018). *Cleaner, smarter, cheaper: Tariff design for a smart future.* Retrieved from https://www.raponline.org/wp-content/uploads/2018/01/rap-ck-mh-aj-network-tariff-design-for-smart-future_2018-jan-19.pdf; CEER. (2020). *CEER Paper on Electricity Distribution Tariffs Supporting the Energy Transition.* Retrieved from https://www.ceer.eu/documents/104400/-/-/fd5890e1-894e-0a7a-21d9-fa22b6ec9da0; and BEUC. (2019). *Consumers and the future electricity grids: How to make flexible consumption a win-win.* Retrieved from: https://www.beuc.eu/publications/beuc-x-2019-059_consumers_and_future_electricity_grids.pdf

of the demand-side options (in line with the efficiency first principle, see Question 3.5 above).

Digitalisation allows for increasingly linking all generators and consumers and optimising their operations to the availability of various infrastructures. This means energy optimisation across the supply chain. Digitalisation can help with optimising markets, infrastructure use and the role of the different actors (especially consumers as new active actors) by bringing scarcity/price signals in close to real time.

Potential increased role for digitalisation at the various levels of the energy system:

- Consumers: Hardware condition for becoming an active consumer via smart meters, equipment automation and energy optimisation at the building level (demand, distributed generation, storage).
- Distribution and transmission networks: Better utilisation of existing grids by making them smart in real time and monitoring their status at high granularity, hence easing the currently conservatively set utilisation range.
- Markets: Access of all potential actors to markets, the role of aggregation and virtual power plants via automatic and optimised dispatch.

Question 4. Are there any best practices or concrete projects for an integrated energy system you would like to highlight?

Several Horizon 2020 projects are looking at these topics, including Enefirst.[30] Several initiatives are highlighted to illustrate examples of smart sector integration in Annex 1.

Question 5. What policy actions and legislative measures could the Commission take to foster an integration of the energy system?

Measures to foster a smart integration of the energy system should be based on the two principles highlighted in Question 1 and/or require the application of these principles by Member States. These measures should allow for:

- An increased take up of enabling technologies.

Building renovations

Building retrofits allow for increasing the role of buildings in an integrated energy system (e.g., reducing energy demand, electrifying end uses and providing flexibility and other energy system services). For new buildings, the Energy Performance of Buildings Directive (EPBD) provides a framework implemented by EU Member States to gradually tighten low-carbon requirements. The EPBD requires all new buildings from 2021 (public buildings from 2019) to be nearly zero-energy buildings. This should result in an increasing share of new buildings fitted with low-carbon heating systems. The impact on existing buildings is less significant, as the EPBD requirements only apply in case of major renovations (affecting more than 25% of the surface area of a building or its

[30] Enefirst. Retrieved from https://enefirst.eu

value). There are, however, opportunities to introduce stricter national minimum standards for existing buildings, for example, applicable at the point of sale or rental.[31] The sector integration we need will (a) convert fossil gas and oil heat to high-efficiency electric heat, while (b) decreasing heat loads overall through high-efficiency renovations. As currently structured, the ETS is tilted against the first objective and does very little to address the second. The Commission should actively explore how to remedy this mismatch between the carbon market and needed carbon reductions. One obvious remedy would be to include fossil heating fuels in a carbon pricing regime. However, the carbon price alone is unlikely to drive the pace of building renovations and heating conversions that we will need to meet carbon targets. A powerful approach would be to increase the fraction of carbon revenues (existing and possibly, new) that is used to leverage building renovations. This could be a key element in the proposed Renovation Wave and in any post-COVID economic recovery programme.

Equipment and appliances

Building codes can also phase out the installation of fossil fuel heating systems in new and existing buildings more explicitly.

Some European countries have already taken steps in that direction with different levels of ambition:

- Denmark banned the installation of oil-fired boilers and natural gas boilers in new buildings in 2013 and, beginning in 2016, also banned the installation of new oil-fired boilers in existing buildings in areas where district heating or natural gas is available.
- Norway has banned oil-fired heating systems in all buildings (new and existing) beginning in 2020. Existing oil boilers will need to be replaced.[32]
- The Netherlands has banned connection to the gas grid for new houses for which building permits are obtained after 1 July 2018.[33]
- The German government announced a ban on installing oil heating systems in all buildings, when a low-carbon alternative is technically feasible, by 2026.[34]

[31] Steuwer, S., Jahn, A., & Rosenow, J. (2019). *Minimum energy efficiency standards for rental buildings in Germany: Untapping health benefits*. Proceedings of eceee Summer Study 2019. Retrieved from https://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2019/7-make-buildings-policies-great-again/minimum-energy-efficiency-standards-for-rental-buildings-in-germany-untapping-health-benefits/

[32] Solsvik, T. (2017). *Oil producer Norway bans use of heating oil in buildings.* Reuters. Retrieved from https://uk.reuters.com/article/us-climatechange-norway/oil-producer-norway-bans-use-of-heating-oil-in-buildings-idUKKBN1961VL

[33] Beckman, K., & van den Beukel, J. (2019). *The great Dutch gas transition.* Oxford, UK: Oxford Institute for Energy Studies, University of Oxford. Retrieved from https://www.oxfordenergy.org/wpcms/wp-content/uploads/2019/07/The-great-Dutch-gas-transition-54.pdf?v=7516fd43adaa

[34] Bundesregierung (Cabinet of Germany). (2019). *Eckpunkte für das Klimaschutzprogramm 2030* (Key points for the 2030 climate protection program). Retrieved from https://www.bundesregierung.de/resource/blob/975202/1673502/768b67ba939c098c994b71c0b7d6e636/2019-09-20-klimaschutzprogramm-data.pdf?download=1

- The UK government has announced that, after 2025, gas and oil boilers will no longer be allowed to be installed in new buildings.[35]
- The Austrian National Council voted in favour of banning the installation of oil boilers in new buildings after 2020.[36]
- The Flemish government is planning to ban oil heating boilers by 2021 in new buildings, as part of deep renovation projects, and in houses where a gas pipeline is available on the street. There is also a plan to ban natural gas connections for new housing developments by 2021.
- The Irish government's Climate Action Plan includes a ban on the installation of oil boilers from 2022 and gas boilers from 2025 in all new dwellings.[37]
- All regions across Poland have ruled to ban the use of coal boilers in new and existing buildings in the next years.[38]

Another important policy measure is appliance standards, including standards for heating systems. Such standards have been pivotal in holding back energy demand according to the IEA. In Europe, appliance standards are set through the Ecodesign Directive. Standards can prevent specific types of heating systems from being sold to consumers and will continue to be a viable tool to phase out the most inefficient heating systems. In principle, appliance standards could also be used to eventually ban fossil-fuel-based heating systems through tighter requirements.

EV charging infrastructure in buildings

The EPBD also foresees a number of obligations supporting the electrification of transport. Member States should consider ambitious implementation beyond the minimum requirements specified in the EPBD, that is, equipping shared parking facilities at residential and nonresidential buildings with charging points or ducting infrastructure.[39]

Interoperability of EV charging services

Developing a European standardised payment system to reduce interoperability barriers[40] would be helpful.

[35] HM Treasury and Hammond, P. (2019). Spring statement 2019: Philip Hammond's speech. Retrieved from https://www.gov.uk/government/speeches/spring-statement-2019-philip-hammonds-speech

[36] Republic of Austria Parliament. (2019). Nationalrat verbietet Ölkesselanlagen in Neubauten ab 2020 (National Council bans oil boiler systems in new buildings as of 2020). (Parliamentary correspondence no. 945.) Retrieved from https://www.parlament.gv.at/PAKT/PR/JAHR_2019/PK0945/index.shtml

[37] Department of Communications, Climate Action & Environment. *Climate action plan*. Retrieved from https://www.dccae.gov.ie/en-ie/climate-action/publications/Pages/Climate-Action-Plan.aspx

[38] Rosenow, J. & Cowart, R. (2020). Polish coal boiler phase-out: An inspiration for clean heat. *Foresight Climate & Energy*. Retrieved from: https://foresightdk.com/polish-coal-boiler-phase-out-an-inspiration-for-clean-heat/

[39] An example for more ambitious implementation guidelines: Electro-mobility Platform recommendations on the EPBD review Guidance Note. Retrieved from https://www.platformelectromobility.eu/wp-content/uploads/2018/02/20180821-EPBD-position-paper_final.pdf

[40] Full review of interoperability-related barriers and solutions, see: Element Energy Limited. (2019). *Implementing Open Smart Charging*. Final report for ZEV Alliance. Retrieved from http://www.zevalliance.org/wp-content/uploads/2019/11/IZEVA-smart-charging.pdf

Create a level playing field across energy carriers: Energy Taxation Directive
As we move increasingly towards electrification of end-uses, it is important that misleading price signals do not stand in the way. Policymakers must ensure that there are no existing institutional cost barriers that could actively disincentivise gas to electric fuel switching. In addition to resolving these basic but fundamental regulatory issues, policymakers must also ensure that electricity pricing allows for smart heat electrification.

- Revamp energy market rules to provide the right incentives.

New market design agreed in 2018 provides a suitable framework for the mobilisation of demand-side resources. Major provisions are:
1. Consider demand resources both in network planning and network operation.
2. Develop regulatory frameworks that incentivise network companies to consider non-wire alternatives (eliminate the bias in favour of capital expenditures).
3. Redesign market regulation to provide a level-playing field for supply and demand resources, not only de jure but de facto as well.

The opportunities provided by the European legislation are only worth as much as the extent to which they are implemented by Member States. The implementation challenge is considerable, as Europe has limited and only recent experience with the expensive use of demand-side resources. It is worth studying examples from the EU and beyond (see Horizon 2020 Enefirst[41] project).

The European Commission could foster the implementation in various ways, by:
1. Assisting national regulators in identifying the gaps between existing national market regulation and the new EU market design requirements and highlighting best regulatory practices.
2. Monitoring the implementation process to ensure swift transposition of the Electricity Directive and application of the Electricity Regulation.
3. Coordinating with distribution system operators' associations and Regional Coordination Centres on how network planning will incorporate demand resources best practices.

The Commission should also initiate both research and direct assistance to Member States and National Regulatory Authorities as they address the regulatory and financial challenges inherent in phasing down the domestic gas grid as gas end-uses are converted to lower-emitting electric services. Gas grid disinvestment will require tariff reforms, accelerated depreciation rules, safety rules and customer protections, and new business models as "gas" companies become "heating" companies. This will require regulatory innovation and shared learning among National Regulatory Authorities, gas utilities and ministries — which could well be supported by Commission action.

See also Question 3.5.

[41] enefirst. *Making the efficiency first principle operational*. Retrieved from https://enefirst.eu/

- Move towards future-proof infrastructure.

Several initiatives shall be considered to ensure that our infrastructure is in line with our vision for a carbon-neutral Europe:

1. The revision of the Trans-European Networks for Energy (TEN-E) Regulation provides an opportunity to move into climate-resilient infrastructure planning.[42]
2. The review of the Alternative Fuels Infrastructure Legislation should include minimum smartness requirements for public charging infrastructure in the transport sector, with a focus on smart charging capabilities.
3. Recovery package: The measures should also be aligned with a vision for a carbon neutral Europe. For example, road-transport-related recovery measures should be based on electrification as the most promising and energy-efficient zero-emission technology.

Annex 1: Best practices

- Danish eFlex project: Load management with heat pumps.

From 2011 to 2012, DONG Energy Eldistribution carried out a trial project to test responsiveness of consumers to incentives for demand-side response. The aim of the project was to identify the most effective incentives that would mobilise demand-side response to defer or avoid grid costs. Most of the participating households had heat pumps installed.

Participating households were provided with a heating automation system with an integrated control unit that would interrupt the heat pump during peak periods and turn it back on when peak periods had passed. Automation was based on price signals from the North Pool day-ahead electricity market and minimum comfort levels. The system allowed users to override the automation if they wanted to.[43]

The project showed that there was significant potential for heat pump load management: On average, customers overrode turn-down events 1% of the time or approximately once in three months.[44] This shows that households do respond to pricing incentives and are receptive to automation based on price signals. The project did find, however, that during periods of extraordinarily cold weather, the potential for flexibility was more limited.

- Hawaii: Water heaters providing flexibility services.

Water heaters are used in many countries to shift demand from peak periods to periods of abundant supply. The thermal storage property of water heaters makes them very

[42] See, for example, E3G. (2020). *Briefing Summary: Benchmarks for the new Trans-European Networks for Energy Regulation (TEN-E)*. Retrieved from https://www.e3g.org/library/briefing-summary-benchmarks-new-trans-european-networks-for-energy-ten-e

[43] Dong Energy Eldistribution A/S. (2012). The eFlex Project.Virum: DONG Energy Eldistribution A/S Department of Grid Strategy.

[44] Sweetnam, T., Fell, M., Oikonomou, E., & Oreszczyn, T. (2019). Domestic demand-side response with heat pumps: controls and tariffs. *Building Research & Information* 47(4), pp. 344–61.

similar to batteries. The associated system benefits are that of avoided generation, avoided transmission and distribution network reinforcement, and the curtailment of wholesale prices in these hours.

Water heaters, if equipped with modern control devices, can participate in frequency regulation and grid balancing services for the power system as well. These grid interactive water heaters (GIWH) can be controlled with near instantaneous response from the operator, and these additional benefits are increasingly valuable in markets with rapid fluctuations in supply due to the large share of renewable sources. The net benefits (considering the extra cost of upgrading the heater) triples, mainly due to the benefit provided for frequency control (see Figure 3 below).

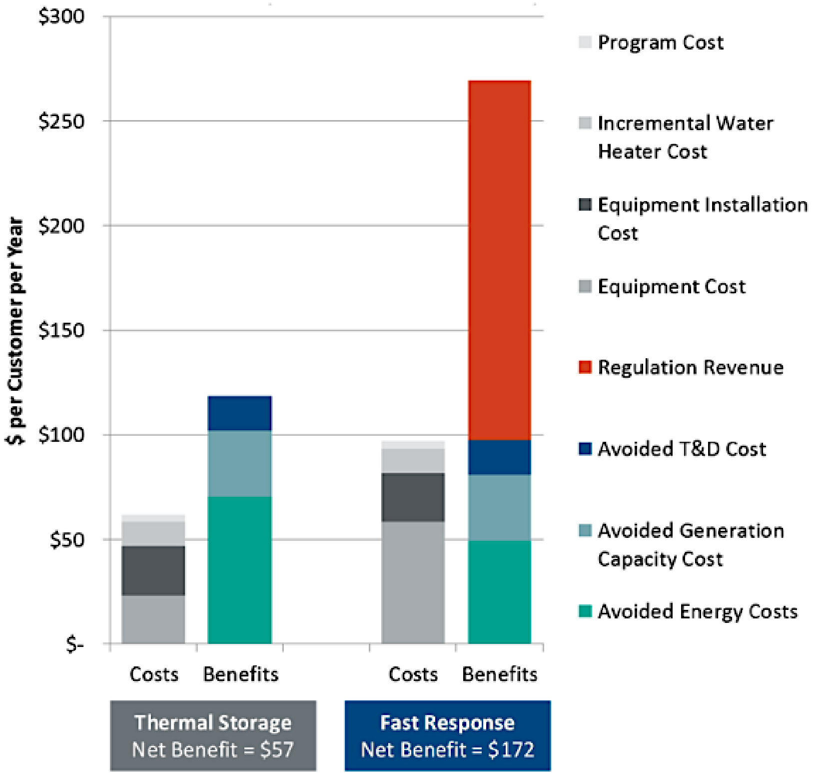

Figure 3: Costs and Benefits for 80-gallon Tank. Source: The Brattle Group, 2016

This, however, can only materialise if market rules allow demand-side resources to participate in ancillary services markets.

In response to the request of the Hawaii Public Utilities Commission, Hawaiian Electric (competitively procured approximately 16 MW of demand capacity. Shifted Energy, partnering with Open Access Technology International, committed to deliver 2.5 MW of grid services with water heaters.[45]

Heaters provide the following grid services:

1. Multihour load shifts, by storing energy during periods of high renewable generation and reducing consumption during peak demand: In Hawaii, peak demand time, 5:00-9:00 p.m. on weekdays, is a time when the grid is strained and when the energy with the highest emissions (oil) is being used.
2. Frequency and voltage regulation: 12-cycle or less response time to frequency or voltage deviations, as well as randomised return-to-load.
3. Emergency demand response: Full fleet shut down to quickly shed maximum kW.

Heaters offer several benefits to the participating GIWH users:

1. Optimises on-site PV self-consumption: coordinating GIWHs as thermal storage units to optimise grid-injected and grid-supplied power exchange for prosumers.
2. Automatically shifts load to off-peak times if the consumer is enrolled in time-of-use and real-time pricing tariffs.
3. Fault detection and alert.

The off-tank controller device is free for the participants and, in return for allowing their water heaters to support grid, they receive a monthly bill credit between $3.00 and $5.00 (approximately between €2.59 and €4.32) over the next five years.

- UK: Tariff designed for enabling smart EV charging

A framework for cost-reflective electricity and network tariffs will enable grid-optimal charging of vehicles, that is, shifting timing of charging to hours with available capacity. Commercial offers for dynamic EV tariffs can be expected to grow with implementation of the Electricity Market Regulation and Directive but are still not sufficient across Europe.

Suppliers in Europe offer specific tariffs for EV users, users with different flexible loads or 'technology-neutral' tariffs that are meant to incentivise smart consumption in general.[46]

Initial results from a small group of first subscribers to one of the available EV tariffs in Europe, the Octopus Agile tariff, show that EV drivers shifted their charging almost entirely away from the peak hours (4:00–7:00 p.m. in Great Britain). One of the features that allowed the average EV driver to save around 132 pounds per year (or around 150 euros), compared with the alternative Octopus Energy 12-month fixed tariff, is that the Agile tariff offers prices linked to the half-hourly wholesale market prices, informing consumers about prices for EV charging one day ahead.

Network tariffs need to become time-varying or to gradually reduce to offer a business case for fast/high-power charging. In Denmark, the regulator requires all grid operators to introduce time-varying pricing by the end of 2020 to send stronger price signals for smart consumption.[47]

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[46] Bhagwat P., & Hadush, S. (2020). *Dynamic retail electricity tariffs: Choices and barriers.* Florence School of Regulation. Retrieved from https://fsr.eui.eu/publications/?handle=1814/66851

[47] Cerius. *Cerius reduces its tariffs and introduces time differentiation* [Translated]. Retrieved from https://cerius.dk/om-cerius/nyheder/pmcerius-reducerer-sine-tariffer-og-indforer-tidsdifferentiering

More information and recommendations:

☐ Hildermeier, J., & Shipley J. (Forthcoming). EV tariff design can optimise grid resources and save drivers money: Selected examples and lessons learned from the U.S. and Europe. Paper submitted to 33rd Electric Vehicle Symposium (EVS33), Portland, Oregon, June 14–17, 2020.

- EVs as storage and flexibility resource across Europe.

Smart technology should assist, and automatise where needed, smart charging and maximise the benefits of tariffs. Or it should assist with energy management systems and additional local storage to optimise charging where shifting the timing of charging is not an option.

Encouraging the combination of EV charging and energy storage for public charging is good practice. Greenway, a fast charging operator in Slovakia and Poland, is testing energy storage systems at locations in those countries, where high-power charging is provided from the grid and a battery, allowing congestion relief, peak-independent charging and better use of renewables. The combination with second-use EV batteries at fast chargers is also being tested by Volkswagen in Wolfsburg.

Charging infrastructure can also enable using EVs for flexibility services by integrating them into local grids, for example into buildings (vehicle-to-building) or the electricity grid (vehicle-to-grid). Selected best practice examples include[48]:

1. Enabling framework conditions to use EVs for grid services: This was tested in Eastern Denmark (with aggregator Nuvve and TSO Energinet) in 2017–2018, where the average revenue at a 10-kW charger was €1,860 per car, per year.
2. Vehicle-to-building: PV-assisted bidirectional public EV chargers providing demand-response for buildings was piloted in Barcelona.[49]

- Integrated mapping of grid and EV charging capacity.

Best practices include:

1. Grid-capacity mapping to identify ideal locations for public fast/high-power chargers.
2. Encouraging municipalities to build appropriate, publicly accessible charging infrastructure at parking areas and transport hubs, helped by performance-based public tenders.

[48] Overview of best practices for EU: SmartEn. (2020). *E-mobility as an energy resource: Collection of best practices to drive regulatory changes*. Retrieved from https://smarten.eu/wp-content/uploads/2020/02/smartEn-e-mobility-publication-2020_for-web.pdf; see also https://northsearegion.eu/media/4308/v2g-projects-in-europe.pdf

[49] Àrea Metropolitana de Barcelona. (2019). *V2G solar PV charging stations: Pilot experiences from local authorities*. https://eusew.eu/sites/default/files/programme-additional-docs/7_F_GilLlado_0.pdf

3. Vehicle purchasing guidelines for municipalities to enable investments in innovative technologies, such as electrification of school buses, including vehicle-to-grid capabilities (best practice in various U.S. programs[50]).

[50] Baumhefner, M., and Muller, M. (2018). Agreement proposed to electrify San Diego's buses and trucks [Blog]. NRDC. https://www.nrdc.org/experts/max-baumhefner/agreement-proposed-electrify-san-diegos-buses-and-trucks