Wind-to-X

A POSITION PAPER ON HOW TO ACHIEVE NET-ZERO EMISSIONS THROUGH A RENEWABLES-BASED ELECTRIFICATION

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EXECUTIVE SUMMARY

NET-ZERO EMISSIONS BY 2050

This paper summarises WindEurope's position on how to achieve net-zero emissions by 2050. It puts forward the **renewable-based electrification** as the most cost-effective approach to reach climate neutrality. This means the conversion of most energy uses in industry and transport from fossil fuels to electricity generated by renewable energy sources, like wind. It stresses the **direct use of this renewable electricity whenever is available and wherever is possible across all sectors in the economy**. And the use of this renewable electricity to produce zero-carbon gases and fuels only where necessary, in those activities which cannot reduce carbon emissions otherwise.

FROM EASIER-TO-ABATE TO HARDER-TO-ABATE SECTORS

First, **Europe must keep the focus in delivering decarbonisation in the easier-to-abate sectors** in order to comply with the Paris Climate Agreement commitments. These include power generation, light-duty transport, rail, pulp and paper, aluminium, buildings, and agriculture. In all these the work is far from over yet. **For these sectors, policymakers should pursue a direct electrification using renewable electricity wherever is available and whenever is possible. This will deliver the bulk of decarbonisation of the economy.**

Crucially, **the EU should continue the implementation and modernisation of policies to mainstream renewable electricity. The regulatory work on direct electrification is not done and over yet**. Significant implementation efforts are needed and many regulatory barriers still exist. These include:

1. **Taxes, levies and tariffs** in the use of electricity, particularly for industrial users;
2. **Energy efficiency accounting methods** which penalise electricity against the use of fossil fuels;
3. **Incentives for the widespread use of heat pumps** particularly in district heating networks and industry;
4. **Incentives for integrating electricity into transport**, particularly in light-duty vehicles.

Second, as Europe progresses on reducing emissions on the easier-to-abate sectors, **it will become increasingly important to focus on the harder-to-abate ones too**. These sectors include heavy industry (cement, steel, and chemicals), heavy-duty road transport, aviation and shipping. Without tackling CO_2 from these activities it will be impossible to achieve net-zero emissions.

In the harder-to-abate sectors, there are certain uses in which direct renewables-based electrification is not technically feasible, or the solutions will be developed too far in the future in order to curb global warming on time. Renewable gases (like biogas or biomethane), as well as gases or liquid fuels produced from renewable electricity (like hydrogen), could decarbonise these harder-to-abate energy uses.

Indirect electrification with renewables should be used only where necessary, like in the hard-to-abate sectors of the economy. Pursuing indirect electrification outside of these sectors would require much higher renewable energy capacities than with direct electrification. This is because using directly renewable electricity is more efficient than converting it into other energy carriers, like hydrogen or hydrogen-based fuels. As the availability of sites and permitting becomes more stringent for renewable electricity, Europe could end up not building enough renewables and importing low and zero-carbon gases from abroad, worsening its energy dependency.

HYDROGEN

Hydrogen can be used in its pure form as an energy carrier, as a combustible gas, in a fuel cell, as a feedstock to produce liquid fuel for heavy-duty transport, or as an industrial raw material. It can also be combined with other inputs to produce what is referred to as hydrogen-based fuels and feedstocks. There are also carbon-based e-fuels which include synthetic methane, synthetic liquid fuels and methanol. In contrast, ammonia is a carbon-free hydrogen derivative which can be used as a chemical and as a fuel.

Over 95 % of hydrogen production today is fossil-fuel based. Only around 4% of global hydrogen supply is produced via electrolysis, a process that splits water into hydrogen and oxygen using electricity, which could be generated by zero-carbon sources, like wind or solar PV. Electrolysers are well developed and commercially available. However**, producing hydrogen with this technology costs roughly double than with fossil-fuels,** which is mostly done with fossil gas in a process called steam-methane reforming (SMR).

While innovation should continue on the integration of electrolysers to the energy system, the focus should be on the support towards industrialisation. Economies of scale and efficiency improvements will reduce costs. In parallel, **the main drivers of the additional costs should be tackled. These are of regulatory nature in the use of electricity, which represents 65-80% of the operational costs of electrolysers**. Tariffs and levies on electricity account for 30% on average of the total electricity bill across the EU. Policy interventions to reduce costs should target to reduce the retail electricity price from these levies, particularly for industrial users. Other opportunities to reduce the cost of hydrogen from renewable electricity include ensuring there is a level-playing-field between different gases, power-to-heat and other storage technologies.

In theory there is the possibility to produce hydrogen with curtailed renewable electricity from wind farms or solar PV plants. **However, there is no business case for this yet and everything indicates that hydrogen production would require dedicated power generation assets**. The installation of this additional capacity for hydrogen production would likely result in a need for more energy imports to the EU. **A first step could be to incentivise energy intensive hard-to-abate industries to locate close to coastal areas,** where offshore wind is abundant, or **to onshore areas with good wind resources and limited transmission.**

SECTOR COUPLING

Sector coupling refers to the increased integration of energy supply-side sectors with all end-use energy consuming sectors. Sector coupling is now well accepted as an important strategy to deliver decarbonisation and other important objectives pursued in energy policy: security of supply and affordability.

One of the major enablers of sector coupling is the conversion of power to gas (PtG or P2G). The resulting hydrogen serves as complementary coupling agent and/or as a feedstock. However **such "cross-vector**

integration"[1] would only contribute to decarbonisation if hydrogen is produced with water electrolysis powered by renewable zero-carbon electricity.

Sector coupling will entail significant regulatory changes. Primarily, the European Commission should adapt the market design and regulatory frameworks adopted with the Clean Energy Package for electricity to the gas sector **by aligning the rules in this latter towards a zero-net emissions pathway.**

This should consist first in a careful assessment of future gas demand, including the use of non-fossil gases limited to specific niches which have basically no other alternative. The next package of legislative proposals for the gas sector, expected in 2020, should avoid **locking-in Europe with fossil gas in the long-term.** It should rather create the conditions for zero-carbon gases to be technical and commercially viable were direct electrification is not possible.

The four areas of priority should be:

1. The **taxonomy** to classify the different routes to produce hydrogen, particularly when produced via electrolysis with renewable electricity;
2. The **traceability** of the renewable electricity used for hydrogen production in a system with a mix of power generating technologies;
3. The **roles and responsibilities of market and regulated players** in the production of hydrogen, crucially who can own, operate and offer sector coupling and cross-vector integration services to the market;
4. The level of **infrastructure needed for cross-vector integration.**

HYDROGEN TAXONOMY

There is no commonly agreed definition and classification for hydrogen at EU-level. The terminology surrounding this potential solution for decarbonising Europe's hard-to-abate sectors can be confusing and potentially misleading.

The regulatory definition and classification given to hydrogen will be crucial to determine its role in the decarbonisation of the energy system and cross-vector integration. And it will determine hydrogen's treatment in the European Commission's State Aid Guidelines for Environmental Protection and Energy.

There are multiple routes for producing hydrogen which involve varying levels of CO_2 emissions and environmental impacts. Such emissions are mainly determined by the process and the feedstock used in the production. The taxonomy and criteria for hydrogen should unambiguously define these different sources and routes.

WindEurope calls for a clear, simple and transparent classification for hydrogen and hydrogen-derivatives in which the electrolysed hydrogen powered by 100% zero-carbon renewable electricity is the reference baseline, avoiding complex definitions to maintain a reliable, trust and integrity information for people.

The definition in the recast Renewable Energy Directive is a good starting point for the taxonomy of hydrogen, but it is not enough as it particularly targets the transport sector under renewable fuels

[1] European Parliament, 2018. Sector coupling: how can it be enhanced in the EU to foster grid stability and decarbonise? Study requested by ITRE, Sector coupling: how can it be enhanced in the EU to foster grid stability and decarbonise?

obligations. The provisions in the Directive are straight forward for accounting the renewable electricity used in the onsite hydrogen production in a closed-looped system. But **when electrolysers are connected to a power grid with a varied energy mix and co-located with other sources of power generation, other approaches to account and trace the origin of electricity are needed**.

European Commission will develop a methodology to better account for the share of renewable electricity used in produced hydrogen with equipment connected to the grid. It is planned that it will adopt a delegated act by 31 December 2021 to supplement the Renewable Energy Directive. WindEurope calls for such methodology to be clarified as soon as possible in close consultation with the wind energy industry.

TRACEABILITY OF HYDROGEN – GUARANTEES OF ORIGIN

The taxonomy of hydrogen will also determine the type and amount of Guarantees of Origin (GOs) given to hydrogen producers when using renewable energy.

Guarantees of Origin for renewable energy play an important role to stimulate final customer's demand for renewable energy. In order to preserve this value, a clear distinction must be ensured between GOs for renewable energy (electricity and hydrogen) and, where applicable GOs for non-renewable energies. Renewable energy GOs should only be issued for energies that are 100% renewable-based.

ROLES AND RESPONSIBILITIES REGULATED AND MARKET PLAYERS

If hydrogen is to play a larger role in sector coupling, **policy makers should clarify regulations in the energy sector with regards to ownership, production, and storage of hydrogen facilities**.

WindEurope calls for TSOs and DSOs not be involved in competitive activities like Power-to-Gas, as they will have a potential conflict of interest when planning, granting access and operating / dispatching infrastructures.

ROLES AND RESPONSIBILITIES FOR DEVELOPING INFRASTRUCTURE

Further development of the power grid infrastructure is a 'no regret' option. Increasing the electricity share in Europe's energy mix would require larger and stronger grids. The ENTSO-E Ten-Year Network Development Plan (TYNYP) foresees €114bn (€10.4bn/year) of investments for grid infrastructure to 2030. **The level of grid investment in grids envisaged by the European Commission decarbonisation strategy is 10 times higher than that**.

While there is room for the optimisation of the existing power grid, the EU and Member States should step up the grid build out significantly. The upcoming TEN-E Regulation revision in 2020 should be aligned towards a renewables-based electrification and prioritise electricity infrastructure.

As the EU's fossil gas demand is set to decrease under all future decarbonisation scenarios to 2050 **WindEurope believes that the role of the European gas infrastructure would be to enable the decarbonisation only where direct electrification is not possible**. In such scenario, it is inevitable that many gas assets would have to be decommissioned and the overall infrastructure downsized accordingly in order to keep the economic fundamentals. A major risk is to keep assets operational for too long locking-in economies with energy carriers with high carbon content. This is especially the case for gas generation assets which could become stranded overnight.

POLICY RECOMMENDATIONS

Europe must make a clear choice in favour of the renewables-based direct electrification of industrial processes, buildings and transport as the key drivers of its decarbonisation strategy. This is the most efficient, sustainable and affordable alternative to deliver net-zero emissions.

AT EU-LEVEL

- Policymakers should mainstream immediately the renewables-based direct electrification of all the easy-to-abate sectors as a priority (power generation, light-duty vehicles, and most industrial processes).
    - The EU should continue to expand renewable energy in the power sector by following closely the implementation of the Clean Energy Package.
    - The EU should work urgently towards removing the barriers to direct electrification:
        - It should continue to seek purposely energy taxation reform to favour renewable electricity use over fossil fuels;
        - It should update relevant legislation with a primary energy factor (PEF) value that triggers the use of electricity where and when it is the more efficient option and recognises its role in improving emissions efficiency;
        - Ensure a level-playing-field between electricity and gases by applying the same principles and methods for determining grid tariffs of both sectors.
    - The EU should support the widespread use of heat pumps in buildings and industry.
    - The EU should incentivise the development of electrical charging infrastructure.
    - The European Commission should define the roles of both direct and indirect electrification as part of its strategy for a smart, innovative and sustainable industry in the context of achieving net-zero emissions by 2050.
- As Europe reduces the emissions from the easier-to-abate sectors, it should prepare the regulatory framework to tackle emissions from the harder-to-abate sectors:
    - It should support the development for the commercialisation of zero-carbon renewables-based gases and fuels by:
        - Target the development and upscaling of electrolyser technologies through industrial policies for securing technology leadership and reducing the cost of renewable hydrogen production;
        - Continue R&I on system integration and pursue research, test, demonstration, incentives for large-scale electrolysers and off-grid connected renewables ;Treat electrolysers using 100% renewable electricity on a level-playing-field with power-to-heat technologies and other storage solutions;
        - Ensure grid tariffs are cost-reflective for P2G injected to the gas network;
        - Mandate an EU-wide framework for permitting requiring Member States to designate “one-stop shop” permitting authorities at national level, and set time-limits on application processes for technologies using renewable electricity, like electrolysers, power-to-heat and storage.
    - Propose a legislative framework to align the fossil gas sector towards net-zero emissions with the following guiding principles:
        - Ensure a level-playing-field and effective competition among future energy carriers: renewable electricity, renewable gases, hydrogen and hydrogen-based fuels from

renewable electricity. Free allowances exclusively for fossil fuel-based hydrogen undermines the effectiveness of the EU ETS.
        - Assess the CO2-footprint of biofuels and electro-fuels.
        - Recognise the role of gases from renewables (like hydrogen) to enable the decarbonisation of the harder-to-abate sectors like heavy-transport, including shipping, and industrial sectors such as cement, steel, and chemicals.
        - Avoid the long-term fossil fuels locking-in while making the best use of existing energy infrastructure.
        - Pave the way for sector coupling.
- Specifically this legislative framework should:
    - Provide an unambiguous and transparent definition and taxonomy for the different sources and routes to produce hydrogen and hydrogen derivatives;
    - Renewable hydrogen and its derivatives should be powered by 100% zero-carbon renewable electricity;
    - Clarify and where needed define the roles and responsibilities of regulated entities (TSOs and DSOs) and market players in the development, operation, gas injection and ownership of hydrogen infrastructure.
        - This should be fully in line with the principles of Third Liberalisation Package of unbundling and reaffirmed in the recent Clean Energy Package;
        - TSOs and DSOs should not be involved in competitive activities that market players can perform more cost efficiently;
        - Set clear rules for supporting hydrogen demonstration projects in case of derogation granted to regulated entities (e.g. definition of market failure, period of involvement, third party access etc.) in order to ensure that the TSO or DSO will not foreclose competition to develop in the future.
- The EU should also complete the pending delegated acts from the Renewable Energy Directive for accounting renewable electricity for electrolysers connected to the grid and clarifying the methodologies for compliance of the renewables fuel obligation (Articles 25-27) as soon as possible. Demand already exists for this renewable hydrogen. However until there is clarity on how/to what extent it contributes to the Renewable Energy Directive II (REDII) targets, it is difficult to reach a final investment decision.
- The European Commission should propose a roadmap on how to incentivise scaling-up and reducing the cost of production of renewable hydrogen, derivative fuels and gases based on renewable energy to enable substituting fossil fuels in hard-to-abate sectors.
- The upcoming TEN-E Regulation revision in 2020 should be aligned towards a renewables-based electrification and prioritise electricity infrastructure.

AT MEMBER STATES LEVEL

- Member States should spell out electrification measures as part of their National Energy and Climate Plans to 2030, notably for industrial processes. Direct electrification efforts should take precedence over the development of indirect electrification options to 2030.
- Member States should take a fresh look at energy taxation both at national and EU-level and support the European Commission proposal for Qualified Majority Voting decision-making in EU taxation policy, notably for energy.

- Member States should remove the non-energy related elements from electricity bills.
- Member States should optimise the power grid and prioritise the development of the power grid infrastructure as a ‘no regret’ measure to decarbonise their economies
- Member States should define how they will enable green procurement for industry, notably by facilitating the uptake of corporate PPAs as mandated by the Renewable Energy Directive
- National Regulatory Authorities (NRAs) should provide a clear and transparent framework to account properly and separately for the Guarantees of Origin (GOs) for renewable electricity and for hydrogen produced from it:
    - GOs should be issued free of charge to all renewable producers who request it including to those receiving financial support. The value of the GOs should be taken into account in the support mechanism in line with the options contained in REDII (Art. 19.2 points (a) to (c));
    - Member States should work towards the decentralisation of the request of issuance of GOs as far as possible, albeit under a centralised certification system.
- In relation to REDII implementation, Member States should:
    - Exempt fuel producers, and particularly electrolyser owners, from the targets on advanced biofuels (Part A of Annex IX) in transport. For electrolyser owners, that produce nothing else than renewable hydrogen (for transport), it would be unreasonable onerous to expect that on the side they produce a percentage of their fuel in the form of advanced biofuels; for other fuel producers preferring to take up renewable hydrogen, it might be complex to also include advanced biofuels.
    - Carefully consider the potential consequences for accounting recycled carbon fuels towards RES targets.
        - Double counting emissions from Carbon Capture and Usage (CCU) under the EU ETS;
        - Lock-in effect by creating business case conditions for industries emitting flue gases;
        - Dis-incentivise research on carbon-free solutions.

1. NET-ZERO EMISSIONS BY 2050

1.1 THE PARIS CLIMATE AGREEMENT

The Paris Climate Agreement committed the world to limit global warming to well below 2°C and keep it as close as possible to 1.5°C above preindustrial levels. Not meeting these commitments could bring significant negative impacts to humans and the planet[2]. In reality, the agreement is a bridge between today's policies and climate neutrality before the end of the century.

The EU has been at the forefront of international efforts to combat climate change. It was the first major economy to submit its intended contribution to the Paris Climate Agreement. The EU aims to reduce greenhouse gas emissions by at least 40% by 2030 compared to 1990, improve its energy efficiency at least 32.5% and have at least 32% share of renewable energy in final energy demand.

2030 is only a milestone in the long-term fight against climate change. Europe is already exploring how to become carbon neutral by 2050 thereby contributing to the 1.5°C goal. The European Commission has analysed the feasibility of eight different pathways to get there, but **only two scenarios would achieve net-zero emissions by 2050[3] (see figure 2)**. Policymakers will be facing significant challenges to lead society towards any of these futures. Some of these are: the acceptability to change the way we produce and consume energy, the pace at which this change should take place, the short-term impacts on the competitiveness of specific sectors in a globalised economy, and the upfront investments needed in the short-to medium-term compared to the long-term results.

This paper summarises WindEurope's position on how to achieve net-zero emissions while addressing some of the challenges mentioned above. It puts forward the **renewable-based electrification** as the most cost-effective approach to reach climate neutrality and as a priority. This means the conversion of most energy uses in industry and transport from fossil fuels to electricity generated by renewable energy sources, like wind. It stresses the **direct use of this renewable electricity whenever is available and wherever is possible across all sectors in the economy**. And the use of this renewable electricity to produce zero-carbon gases and fuels only where necessary, in those activities which cannot reduce carbon emissions otherwise. Efforts to maximise direct electrification should be undertaken with priority over indirect electrification.

1.2 POLICY OPTIONS TO ACHIEVE CARBON NEUTRALITY

There is a combination of three general approaches that policymakers are exploring to decarbonise economies: 1) reducing resources demand - through energy efficiency, circular economy, or life style/behaviour changes-; 2) technology options to decarbonise the energy supply – like fuel-switching, renewable sources, hydrogen or other zero-carbon fuels-; and 3) the use of sinks or absorption technologies of CO_2 - like CCS.

First, it has been well established that **overall energy consumption must be reduced and optimised through energy efficiency measures**. This is the cheapest CO_2 abatement strategy for most sectors.

[2] International Panel on Climate Change (IPCC), 2018. Special report: Global warming of 1.5°C. https://www.ipcc.ch/sr15/

[3] European Commission, 2018. In-depth analysis in support of the commission communication COM (2018)773. A clean planet for all. A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy.

Achieving net-zero emissions will require rapid improvement in energy efficiency particularly in buildings and industry. While there is significant room for improvement in the former, energy efficiency measures in industry are unlikely to yield more than 10-15% reduction in the overall energy consumption of the economy[4]. Therefore, the next abatement opportunity for industry is to decarbonise its energy supply.

As the power sector has been historically one of the largest CO_2 emitters, decarbonising its supply has been and continues to be a priority. So far this has successfully been achieved largely thanks to renewables. But electricity currently only accounts for 24% of the total energy consumption in Europe. 45% is consumed in heating and cooling applications for buildings and industrial processes and a further 31% in transport. These sectors are currently dominated by fossil fuels. **Converting as many as possible of these energy uses to consume renewable electricity will be crucial to decarbonise.**

This electrification of the economy would further contribute to reduce energy consumption as the efficiency of electricity is in many cases higher than the equivalent thermal process. As an example, a battery electric vehicle has higher efficiencies (>65%) than an internal combustion engine vehicles (<30%) or an electric fuel cell vehicle (<30%).

Third, in order to achieve the 'less than 2°C degrees goal', and have any chance to achieve the 1.5°C limit, it is essential that **energy and industrial systems achieve net-zero emissions without relying on natural carbon sinks**, like offsets from land use or oceans. There will be significant efforts needed to restore and improve carbon sinks, but overall these opportunities are expected to decrease globally and will be insufficient on their own[5].

1.3 FROM EASIER-TO-ABATE TO HARDER-TO-ABATE SECTORS

Europe has endeavoured to reduce its CO_2 emissions for the last 20 years. It started with the easier-to-abate sectors, like power generation[6]. Other easier-to-abate sectors include light-duty transport, rail, pulp and paper, aluminium, buildings, and agriculture. Together they emit 70% of global emissions[7]. In all these the work is far from over yet. While these sectors have cheaper CO_2 abatement costs, significant policy efforts are still needed. **Europe must keep the focus in delivering decarbonisation in the easier-to-abate sectors** in order to comply with the Paris Climate Agreement commitments and combat climate change**.**

Decarbonising the power sector has been the fastest from all the easier-to-abate sectors. Driven by the large-scale substitution of fossil fuels for renewable energies, the CO_2 emissions in this sector have dropped 23%, from 1.7 $MtCO_{2eq}$ to 1.3 $MtCO_{2eq}$ between 2005 and 2015 in Europe[8]. In the same period electricity generation from renewables doubled, from roughly 450 TWh/year to around 920 TWh/year[9].

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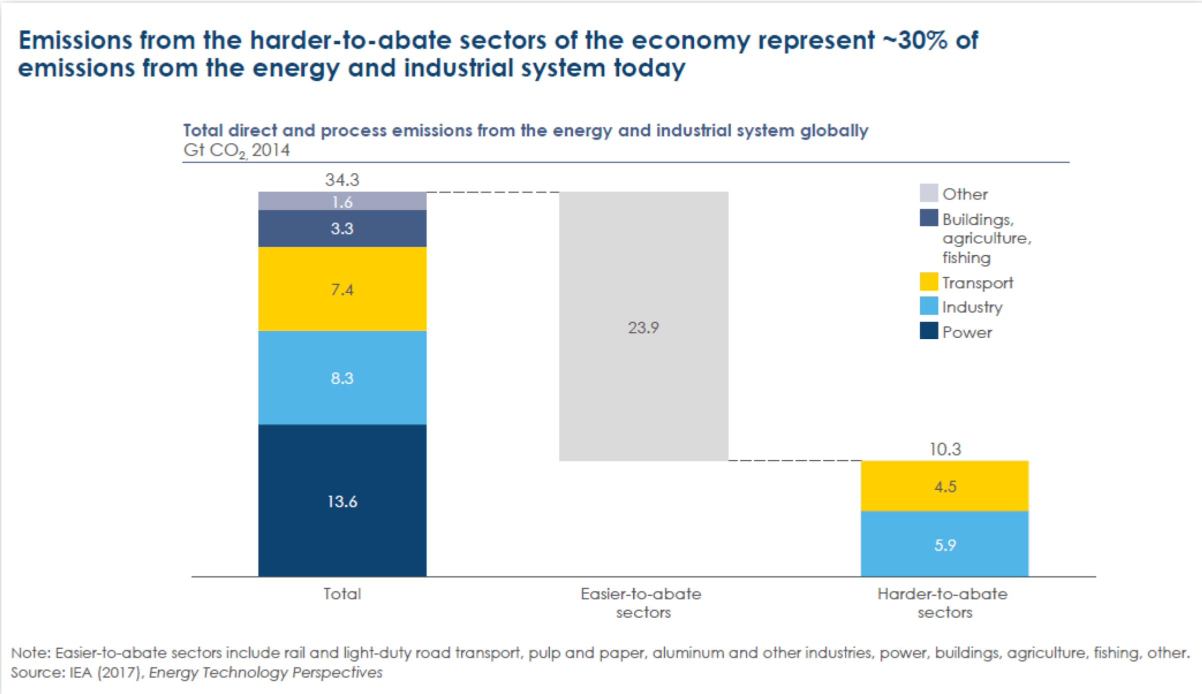
[4] As competitiveness pressures are felt mostly by industry, businesses where energy represent a significant part of their operation costs are run already tight. And growth expectations may offset some energy savings in absolute terms. Energy Transitions Commission, 2019. Mission Possible - Reaching net-zero carbon emissions from harder-to-abate sectors by mid-century.
[5] European Commission, 2018. Ibid
[6] Easier-to-abate sectors are those sectors of the economy that can abate carbon at negative costs or below $40/t$CO_2$
[7] Energy Transitions Commission, 2019. Ibid. Data from IEA, 2014
[8] https://www.eea.europa.eu/data-and-maps/indicators/greenhouse-gas-emission-trends-6/assessment-2
[9] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Figure_5-Gross_electricity_generation_from_renewable_sources_EU-28_1990-2017.png

In order to meet Europe's climate and energy targets, renewables should produce close to 60% of electricity by 2030 and more than 80% by 2050 (see section 2).

As Europe progresses on reducing emissions on the easier-to-abate sectors, **it will become increasingly important to focus on the harder-to-abate ones too**. These sectors include heavy industry (cement, steel, and chemicals), heavy-duty road transport, aviation and shipping. Without tackling CO_2 from these activities it will be impossible to achieve net-zero emissions.

Together the harder-to-abate sectors represent around 30% of CO_2 emissions globally[10]. In heavy industry, iron and steel emit roughly 6% of global emissions, cement production 7%, and chemicals 5-7%. Heavy-duty transport (freight road, shipping and aviation) contributes with around 8%-10%[11].

Figure 1 – Emissions from the harder-to-abate sectors, global figures. Source: Energy Transitions Commission, 2019



In order to reach a fully decarbonised economy we must reduce and eventually eliminate emissions from the harder-to-abate sectors. Crucially, because the share of emissions from these will increase in the future, not only due to economic growth, but also because the rest of the sectors in the economy will decarbonise faster.

The greatest decarbonisation challenge lies within those sectors where industrial processes require high temperature heat and/or where the chemical transformations involve emissions of CO_2 (called process emissions). **Steel, cement and chemicals production are the most important harder-to-abate sectors** with these characteristics not only because its emissions contribution, but also because their growth forecast. As such, these sectors have particular challenges of competitiveness against international

[10] Energy Transitions Commission, 2019. Ibid. Data from IEA, 2014

[11] IRENA, 2018. Hydrogen from renewable power. Technology outlook for the energy transition

markets without emission limits and/or low-carbon obligations. Therefore, preventing the de-localisation of operations (carbon leakage) during the energy transition is critical. However, a first-mover advantage for countries which promote and adopt standards and low-carbon products could emerge[12]. For Europe, this would secure industrial competitiveness in the long-run.

2. RENEWABLES-BASED ELECTRIFICATION TO DECARBONISE EUROPE

Electrification is the integration of final energy uses into the power sector. It can take place directly by substituting fossil fuels with electricity in heating, industrial processes or transport, or indirectly by converting electricity into another energy carrier, like hydrogen or hydrogen-based fuels, which then can be used by consumers. However, for electrification to contribute to climate change mitigation it would have to come from zero-carbon energy sources. This is why Europe should use renewable electricity to decarbonise across all sectors of the economy.

Policymakers should pursue a direct electrification using renewable electricity wherever is available and whenever is possible. This will deliver the bulk of decarbonisation of the economy. To achieve this, it must continue the deployment of renewable energy technologies and storage. This expansion, together with the increased number of applications and uses, will allow the continuation of technology cost reductions, which have progressed rapidly in the last years.

Indirect electrification with renewables should be used only where necessary, like in the hard-to-abate sectors of the economy. This is particularly important when taking decisions for future infrastructure investments. While power grids reinforcement and build-out should be seen as a no-regret option, the further expansion and adaptation of infrastructure for gases and fuels poses the risk of locking-in economies with stranded assets.

The 2050 decarbonisation strategy proposed by the European Commission shows that final energy demand should decrease drastically while **electricity use should increase significantly from the 24% share of final energy demand in 2030 to 50% if Europe is to achieve net-zero emissions goal in 2050** (see 1.5 TECH and 1.5 LIFE scenarios in Figure 2) [13]. The other half of final energy demand would be met by a combination of biomass, fossil gas, hydrogen, hydrogen derived e-fuels[14]. Combined, hydrogen and e-fuels could meet up to 24% of final energy demand in 2050. Crucially, the European Commission scenarios also show that **wind energy would need to make up close to 50% of Europe's electricity mix in order to reach net-zero emissions**.

[12] Industrial Transformation – Pathways to Net-Zero Emissions of Heavy Industry", Material Economics (2019)
[13] European Commission, 2018. In depth analysis in support of the Commission Communication COM 2018)773. A Clean Planet for All. A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy.
[14] Includes e-gases and e-liquids

Figure 2 – Share of energy carriers in final energy consumption, European Commission, 2018

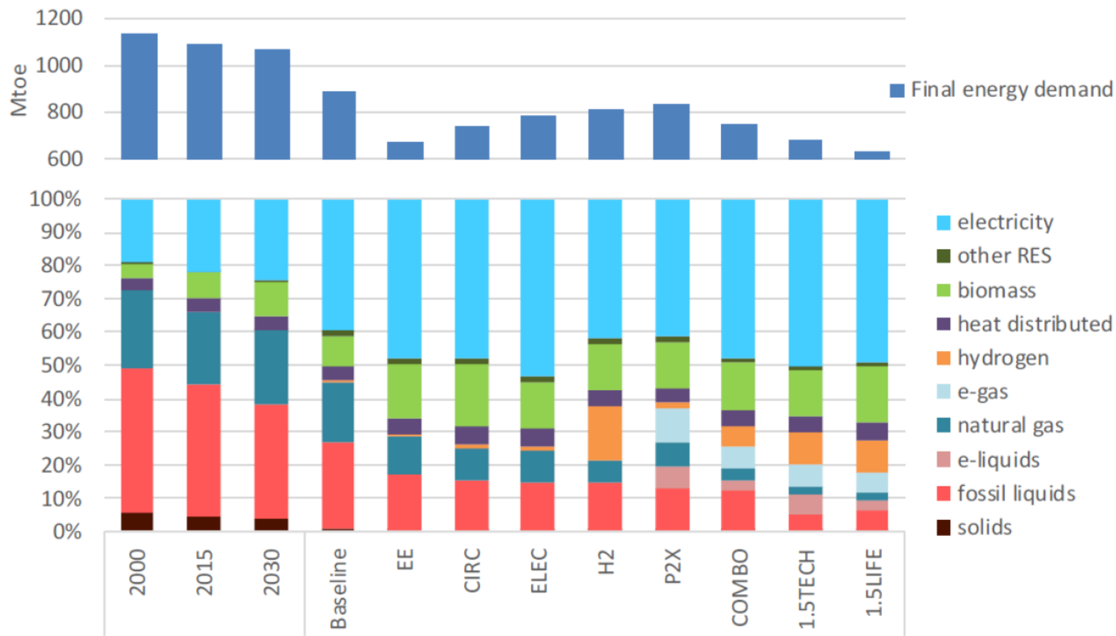
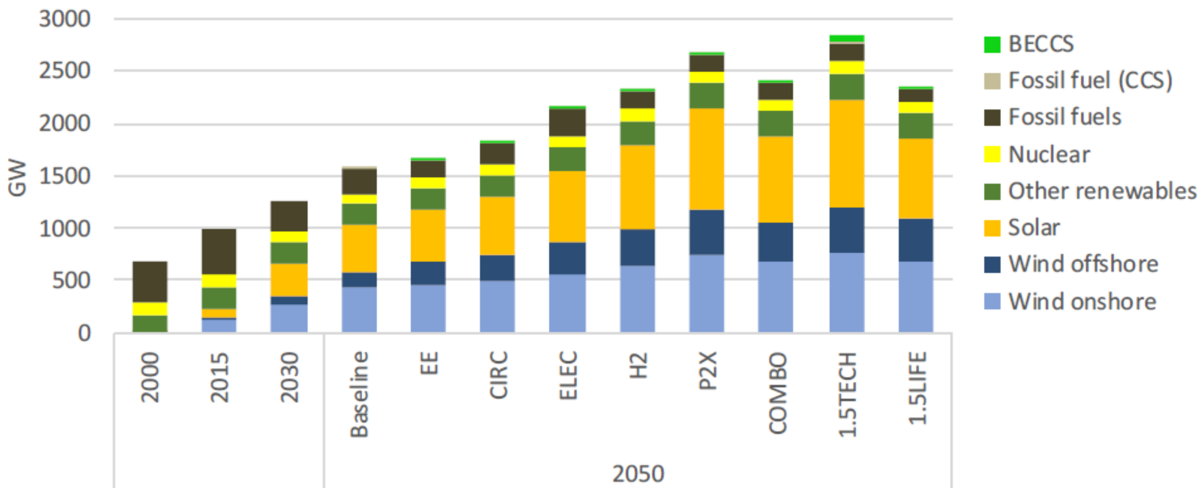


Figure 3 – Energy mix in 2050 across different decarbonisation scenarios, European Commission 2018



Source: Eurostat (2000, 2015), PRIMES.

WindEurope's report Breaking New Ground shows a more ambitious 62% electrification rate based on renewables by 2050[15]. In this scenario, the final energy demand is set to decrease by 33% and would put Europe in line to meet the 'less than 2°C degrees goal' from the Paris Climate Agreement.

The Energy Transitions Commission, a coalition of business, finance and civil society leaders, has recommended **electrification as the option with the greatest role in reaching net-zero emissions by mid-**

[15] It would cost 2.7% of Europe's annual GDP to 2050, only 0.5 percentage points more than achieving 50% electrification. But being more ambitious would save climate change mitigation costs from 1.2% of Europe's annual GDP to 0.86%.

century. In their view, electricity should account to roughly 65% of final energy demand in 2050, of which 85-90% will be coming from renewables or other zero-carbon sources. Noteworthy, the Commission forecast that no more than 10-15% of global electricity will come from biomass or fossil fuels with CCS, giving variable renewables like wind and solar PV, the largest share in the power system.

2.1 DIRECT ELECTRIFICATION

There are significant benefits in pursuing a large-scale, direct renewables-based electrification for Europe. Beyond climate change mitigation, benefits include decrease air pollutants, reduce fuel imports, dependency, increased energy efficiency of the economy, and hedging future energy bills for consumers. These benefits are central to maintaining quality of life for citizens and the competitiveness of businesses.

First, health-related economic costs of air pollution in the EU are between €300 bn and €940 bn annually, equivalent to 3-9% of the EU's GDP[16]. Displacing fossil fuels from industry and transport would **reduce the exposure of large parts of the European population to dangerous pollutants** such as SO2, NOx and particle matter.

Second, 20% of all EU's imports are energy-related. The EU imports 90% of its crude oil, 66% of its natural gas, 42% of its coal and 40% of its uranium and other nuclear fuels. That accounts for 54% of all the energy it consumes costing EU citizens more than €1bn per day[17]. Replacing fossil fuels with domestic renewable electricity would significantly **decrease import dependency, improve the EU's energy security and would translate into imports costs savings for consumers**.

Third, cost savings would become greater as the efficiency of the power system and of electrical end-use technologies and appliances increases**. Electrification would help to reduce final energy demand as the production of renewable electricity has no conversion losses** and it can deliver equivalent services with less energy input.

Fourth, increased electrification will help to **integrate larger shares of variable energy generation more quickly.** The additional electricity demand from transport, heating and industry could help to better match supply and demand if coupled with digitalisation, smart grids, and demand side response. Storage would eventually provide additional flexibility. The coordination and increase in all these sources of flexibility will be essential to minimise the system reliance on fossil fuel electricity generation.

2.2 INDIRECT ELECTRIFICATION

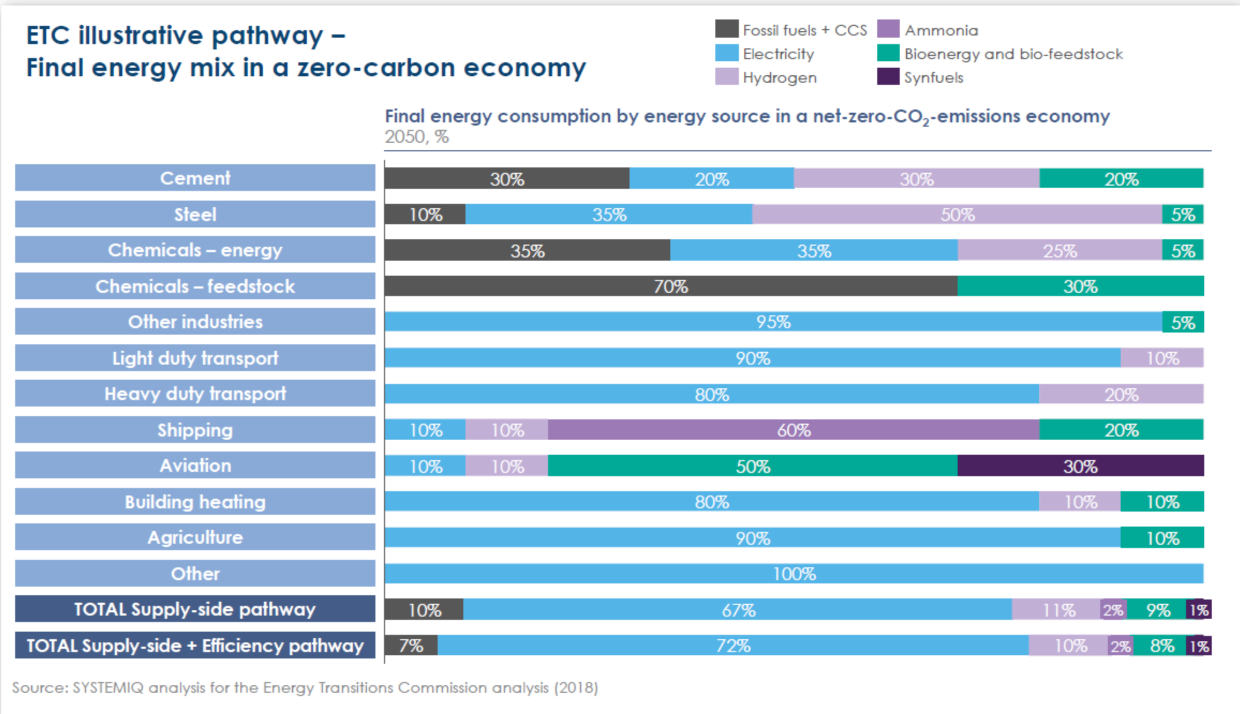
There are certain uses in which direct renewables-based electrification is not technically feasible, or the solutions will be developed too far in the future in order to curb global warming on time. Renewable gases (like biogas or biomethane), as well as gases or liquid fuels produced from renewable electricity (like hydrogen), could decarbonise these harder-to-abate energy uses. This indirect electrification will be an important complement for achieving net-zero emissions. Efforts to maximise direct electrification should be undertaken with priority over indirect electrification.

[16] European Commission Memo, 18 December 2013. http://europa.eu/rapid/press-release_MEMO-13-1169_en.htm
[17] Energy Security Strategy, European Commission, 2015. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52014DC0330&-qid=1407855611566

However, policymakers should be aware that a pathway of energy demand with indirect electrification not limited to specific sectors without other alternative to decarbonise would require considerably higher renewable energy capacities than with direct electrification**.** This is because using directly renewable electricity is more efficient than converting it into other energy carriers, like hydrogen or hydrogen-based fuels. Moreover, the infrastructure requirements for indirect electrification, if not planned carefully, could risk offsetting the energy efficiency savings from direct electrification[18]. Furthermore, as the availability of sites for renewable electricity generation gets more difficult, Europe could end up importing zero- and low-carbon fuels from abroad, increasing further - rather than improving - its energy dependency.

Indirect electrification therefore should be pursued only where necessary, for example in the harder-to-abate sectors of the economy.

Figure 4 – Illustrative pathway to achieve net-zero emissions, Energy Transitions Commission, 2018



2.3 HYDROGEN

Hydrogen is not an energy source but an energy carrier, like electricity. This means both have similarities with one another. Hydrogen and electricity can be produced by various energy sources and technologies. Both are versatile and can be used in many different applications. However, both can have a high CO_2 intensity upstream if produced from fossil fuels such as coal, oil or natural gas. They can also come from CO_2 free sources like renewables and nuclear energy or its CO_2 content can be reduced through the use of CCUS or CCS[19].

[18] The European Climate Foundation, 2019. Towards fossil-free energy in 2050
[19] CCUS – Carbon Capture Usage and Storage.
CCS – Carbon Capture and Storage

The crucial difference between hydrogen and electricity is that hydrogen is a chemical energy carrier, composed of molecules and not from electrons as electricity. This distinction underpins all the reasons why hydrogen might be more feasible than direct electrification in some situations (and vice versa). Chemical energy is attractive because it can be stored and transported in more different ways than electricity.

Using electricity, on the other hand, **is more efficient when it is coming from renewable sources like wind and solar PV.** After converting electricity to hydrogen, shipping it and storing it, then converting it back to electricity in a fuel cell, the delivered energy can be below 30% of what was in the initial electricity input. This makes hydrogen more "expensive" than electricity or the natural gas used to produce it. It also makes a case for minimising the number of conversions between energy carriers in any value chain. This poses a challenge for widespread use versus direct electricity.

However, **hydrogen can be used in its pure form as an energy carrier, as a combustible gas, in a fuel cell, as a feedstock to produce liquid fuel for heavy-duty transport, or as an industrial raw material**. It can also be combined with other inputs to produce what is referred to as hydrogen-based fuels and feedstocks. These can be produced using hydrogen from any source, whether it is electricity, biomass or fossil fuels. And it can readily be used in applications such as engines, turbines and chemical processes. There are also carbon-based e-fuels which include synthetic methane, synthetic liquid fuels and methanol. In contrast, ammonia is a carbon-free hydrogen derivative which can be used as a chemical and as a fuel.

Over 95 % of hydrogen production today is fossil-fuel based. Only around 4% of global hydrogen supply is produced via electrolysis[20], a process that splits water into hydrogen and oxygen using electricity, which could be generated by zero-carbon sources, like wind or solar PV. Electrolysers are well developed and commercially available. However**, producing hydrogen with this technology costs roughly double than with fossil-fuels[21],** which is mostly done with fossil gas in a process called steam-methane reforming (SMR).

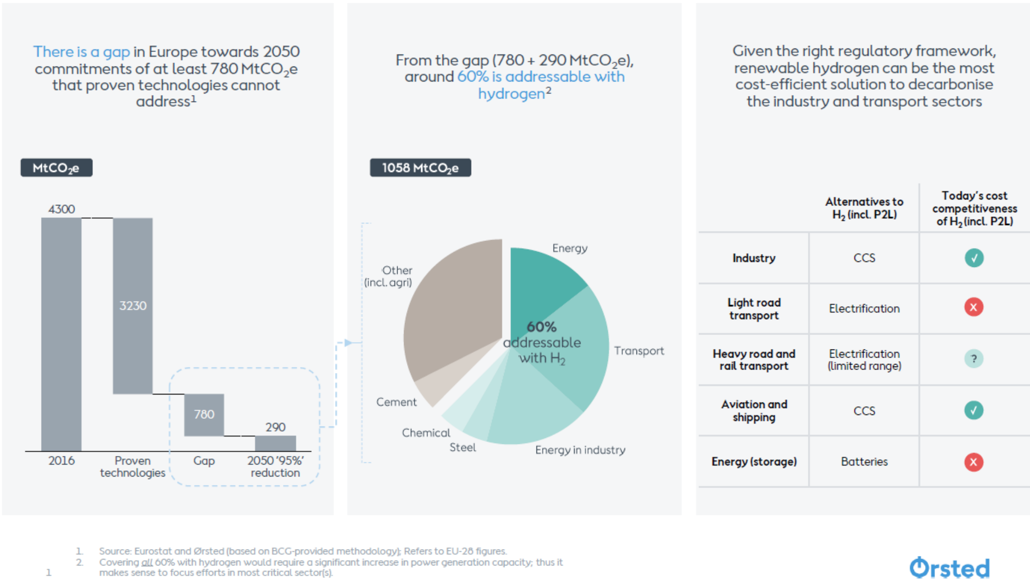
While innovation should continue on the integration of electrolysers into the energy system, the focus should be on the support towards upscaling and industrialisation. Economies of scale and efficiency improvements will reduce costs including for large testing facilities. In parallel, **the main drivers of the additional costs should be tackled. These are of regulatory nature in the use of electricity, which represents 65-80% of the operational costs of electrolysers[22]**. Tariffs and levies on electricity account for 38% on average of the total electricity bill for industry across the EU[23]. Policy interventions to reduce costs should target to reduce the retail electricity price. Other opportunities to reduce the cost of hydrogen from renewable electricity include **making cost-reflective the grid tariffs when it is injected into gas pipelines**. Policymakers should ensure there is a level-playing-field between different gases, power-to-heat and other storage technologies.

[20] IRENA, 2018. Hydrogen from renewable power. p. 13
[21] IEA, 2019. The Future of hydrogen. p.55
[22] IEA, 2019. The Future of hydrogen. p.55
[23] European Commission, 2018. Energy prices and costs in Europe. Commission staff working document. p.38 https://ec.europa.eu/energy/sites/ener/files/documents/swd_-_v5_text_6_-_part_1_of_4.pdf

In parallel a **fairer competition among the different types of hydrogen (and electricity) must be ensured**. Fossil-based hydrogen receives a significant number of EU ETS allowances for free, while hydrogen from renewable electricity does not[24]. To ensure correct incentives to switch to renewable hydrogen, there cannot be preferable treatment of fossil sources of hydrogen. Free allowances exclusively for fossil hydrogen undermines the effectiveness of the EU ETS. To ensure correct incentives to switch to renewable hydrogen, there cannot be preferable treatment of fossil sources of hydrogen.

If these measures are implemented, hydrogen produced with renewable electricity could replace fossil-based hydrogen in the harder-to-abate sectors of the economy. There is a gap in Europe of at least 780 MtCO2e towards net-zero in 2050 that proven technologies cannot address.

Figure 5 – The rationale for renewable hydrogen in the EU, source: Ørsted



Hydrogen produced with renewable electricity could replace fossil-based hydrogen feedstocks in industry. These include for example ammonia, of which the chemicals sector uses 65% of the global demand to produce fertilisers, polymers, resins and other chemicals (through the production of methanol). The second largest use is for the refining of fuels (25%). But other large energy users such as iron, steel, and glass, electronics, and speciality chemicals use hydrogen too[25]. Their combined share of total global demand is small (around 10%), but they represent the last and most difficult sectors to decarbonise. Without the substitution of the fossil fuel-based hydrogen, many of these sectors cannot achieve net-zero emissions. Refineries in the EU will be able soon to use renewable-based hydrogen to reduce the carbon footprint of conventional fuels. The Renewable Energy Directive II foresees this development as today only biofuels blending is allowed.

Also **hydrogen could be a viable option for decarbonising certain modes of transport, like heavy-duty transport in road, aviation and shipping sectors**. Hydrogen offers an alternative for zero- emission transportation, due to long range, high payload and a refueling time which is comparable to conventional

[24] Fossil-based hydrogen production is listed as an activity that receives ETS allowances under Annex I of the ETS regulation. Hydrogen produced using wind and solar PV electricity does not produce CO2 emissions therefore is not listed in Annex I.
[25] IRENA, 2018. Hydrogen from renewable power. Technology outlook for the energy transition.

fuels. This would benefit in particular public transport authorities and the heavy-duty sectors. Effective measures to incentivise the use of hydrogen EVs would be **guidelines for the introduction of zero-emission vehicles for public operators** and **substantial tax incentives and toll exemptions for commercial truck operators.**

In theory there is the possibility to produce hydrogen with curtailed renewable electricity from wind farms or solar PV plants. **However, there is no business case for this yet and everything indicates that hydrogen production would require dedicated power generation assets**. The installation of this additional capacity for hydrogen production would likely result in a need for more energy imports to the EU. **A first step could be to incentivise energy intensive hard-to-abate industries to locate close to coastal areas,** where offshore wind is abundant, or **to onshore areas with good wind resources and limited transmission.**

3. SECTOR COUPLING

For Europe to reach net-zero emissions it will require a combination of mainstreaming electricity in the energy sector and the use of cleaner gases and fuels where direct electrification is not possible. Given the long life of energy assets and infrastructure planning, the EU should focus its policies on direct electrification while allowing for the synergies between sectors.

Sector coupling refers to the increased integration of energy supply-side sectors with all end-use energy consuming sectors. It aims at improving the efficiency and flexibility of the energy system as well as its reliability and adequacy so that decarbonisation can be achieved in a more cost-effective way[26]. Sector coupling is now well accepted as an important strategy to deliver decarbonisation and other important objectives pursued in energy policy: security of supply and affordability.

One of the major enablers of sector coupling is the conversion of power to gas (PtG or P2G). The resulting hydrogen serves as complementary coupling agent and/or as a feedstock that could be delivered to commercial consumers or individuals, or eventually injected into the gas grid. Alternatively, this hydrogen could be stored and become a source of seasonal flexibility in the power sector if a mature and well-functional ancillary service market is in place. However, **such "cross-vector integration"[27] would only contribute to decarbonisation if hydrogen is produced with water electrolysis powered by renewable zero-carbon electricity**.

Sector coupling will entail significant regulatory changes. The European Commission should adapt the market design and regulatory frameworks adopted with the Clean Energy Package for electricity to the gas sector **by aligning the rules in this latter towards a zero-net emissions pathway.**

This should consist first in a careful assessment of future gas demand, including the use of non-fossil gases limited to specific niches which have basically no other alternative. The next package of legislative proposals for the gas sector, expected in 2020, should avoid **locking-in Europe with fossil gas in the long-term.** It should rather create the conditions for zero-carbon gases to be technical and commercially viable

[26] Based on definition of sector coupling from the European Parliament.
http://www.europarl.europa.eu/RegData/etudes/STUD/2018/626091/IPOL_STU(2018)626091_EN.pdf
[27] European Parliament, Ibid

were direct electrification is not possible. Moreover, it should set the rules for coupling electricity and gas infrastructure where and when is the most optimal way to reach net-zero emissions by "cross-vector integration". Last, it should focus on how to create the right market conditions and a regulatory framework that recognises the value of the greenest and most efficient solutions and of other benefits from sector coupling, **like flexibility provision to the power system**. This will establish a level-playing-field in which fair competition can take place and deliver the most efficient outcomes.

The EU should continue the implementation and modernisation of policies to mainstream renewable electricity. The regulatory work on direct electrification is not done and over yet. Significant implementation efforts are needed and many regulatory barriers still exist. These include:

1. **Taxes, levies and tariffs** in the use of electricity, particularly for industrial users;
2. **Energy efficiency accounting methods** which penalise electricity against the use of fossil fuels;
3. **Incentives for the widespread use of heat pumps** particularly in district heating networks and industry;
4. **Incentives for integrating electricity into transport**, particularly in light-duty vehicles.

On the other hand, the regulatory issues to pave the way for cross-vector integration and the market uptake for hydrogen are many and are complex. The four areas of priority should be:

1. The **taxonomy** to classify the different routes to produce hydrogen, particularly when produced via electrolysis with renewable electricity;
2. The **traceability** of the renewable electricity used for hydrogen production in a system with a mix of power generating technologies;
3. The **roles and responsibilities of market and regulated players** in the production of hydrogen, crucially who can own, operate and offer sector coupling and cross-vector integration services to the market;
4. The level of **infrastructure needed for cross-vector integration.**

All the above issues are expanded in the following chapter.

4. SHAPING 2030 TO REACH 2050

4.1 POLICIES TO INCENTIVISE DIRECT ELECTRIFICATION

TAXES AND LEVIES

Switching processes in industry to electricity will rely primarily on fuel costs and the cost of electricity. The decreasing electricity prices, driven by cost reductions in wind and solar could make this an attractive business proposition. However, the level of taxes and levies and the distribution among fuels and energy consumers would have to change. A strengthened CO_2 price, and proper accounting of other externalities of fossil fuels are of course the foundation of any level-playing-field for this appraisal.

Today, taxes and levies represent on average 38% of retail electricity price in the EU[28]. These are one of the reasons why the fall in wholesale prices over the last years had not translated into a lower electricity bills for end-consumers[29]. According to the European Commission, retail electricity prices for industry have risen about 2% a year since 2008 and gas retail prices by 1.75%. The ratio between electricity, gas and oil prices remained quite stable over time to the detriment of electric technologies, although significant differences exist between Member States. Electrification is stifled by this price differential.

In 2011 the European Commission presented a proposal to revise the Energy Taxation Directive with a view to support the EU's wider environmental and energy goals. The proposal was withdrawn in 2015 following the unsuccessful negotiations in the Council of the EU. The process has been revived in January 2019 when the Commission kick-started the debate on reforming the decision-making process for areas of EU taxation policy, which currently requires unanimity among Member States. This unanimity often cannot be achieved on crucial tax initiatives, and can lead to costly delays and sub-optimal policies[30].

The Commission is suggesting a roadmap for a progressive and targeted transition to qualified majority voting (QMV) under the ordinary legislative procedure in certain areas of shared EU taxation policy, as is already the case with most other EU policy areas. This possibility is envisaged by the EU Treaties[31].

WindEurope call for Member States to take a fresh look at energy taxation and support the European Commission proposal for Qualified Majority Voting decision-making in EU taxation policy, notably for energy.

GRID TARIFFS

Gas and electricity should compete on a level-playing-field by applying comparable principles and methodologies to determining the grid tariffs of both sectors. Grid tariffs should be cost-reflective, transparent, and non-discriminatory as stated in Article 18(1) of the Electricity Regulation[32].

In addition, policymakers should reflect the following principles on grid tariffs in any future regulatory framework for sector coupling:

- **Signals to customer must be aligned with the actual grid cost structure.** There should not be *ad-hoc* grid tariff arrangements in markets where electricity and gas compete, or for specific grid users (e.g. storage, power-to-gas, or power-to-heat), as this would contradict the non-discrimination principle;
- **Total grid tariff proceeds must be sufficient to recover the allowed revenues for the grid owners.** This means that tariffs have to allocate all the grid costs – including those that are non-marginal – in the least distortive manner. In doing so, policymakers should avoid that gas and electricity

[28] European Commission, 2018. Energy prices and costs in Europe. Commission staff working document. p.38 https://ec.europa.eu/energy/sites/ener/files/documents/swd_-_v5_text_6_-_part_1_of_4.pdf
[29] For example in Italy, the process to implement a cost-reflective tariff for household consumers is now envisaged to be completed until 2020, after postponing twice its deadline. Crucially, the electricity bill contains significant non energy-related elements like the TV license (C*anone TV*)
[30] European Commission, 2019. http://europa.eu/rapid/press-release_IP-19-225_en.htm
[31] Ibid.
[32] Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity. https://eur-lex.europa.eu/legal-content/EN/TXT/?toc=OJ%3AL%3A2019%3A158%3ATOC&uri=uriserv%3AOJ.L_.2019.158.01.0054.01.ENG

storage pay double charging for accessing their respective grids. Storage assets should pay for (a) the variable costs of the charge and discharge of energy (two charges), and only once for (b) the fixed costs corresponding to their access to the grid (a single charge);

- **Avoid cross-subsidisations between different grid users.** For example, between large industry, SMEs, and households. However, P2G, which uses both the electricity and gas grids, should be subject to both the electricity grid tariff (variable cost corresponding to the electricity consumption together with the fixed costs for access to the grid) and the gas grid tariff (variable costs corresponding to the gas injection and the fixed costs corresponding to the access to the gas grid). If P2G is exempt from any of these grid tariffs, then there would be a cross-subsidy from the rest of grid users.

Ensuring a level-playing-field between the gas and electricity sector is not just a matter of grid tariffs. Market participants face additional charges, levies and taxes that in some cases are larger than the grid tariffs themselves. While the power sector is part of the ETS, in many Member States there are sectors not subject to any CO_2-related cost like fossil gas used for mobility or heating. This is unfairly damaging electricity competitiveness vis-à-vis gas and, as a consequence, the necessary electrification process itself and its positive effects (see section 2.1).

ENERGY EFFICIENCY ACCOUNTING METHODS

The way companies account for energy savings under stringent energy efficiency regulations stifle electrification. The updated Energy Efficiency Directive (EED) and the Energy Performance Buildings Directive (EPBD) established that savings in electricity shall be multiplied by a primary energy factor (PEF) of 2.1[33]. This assumes that all power generation in the EU has an average 40% efficiency rate, which is approximately equal to the energy conversion efficiency of a conventional power plant. This value incentivises electricity savings over direct fossil savings to meet the energy efficiency target, and does not reflect the transition of the EU power mix towards larger shares of renewable energy sources from which energy is harnessed without the burning or combustion of a fuel.

The PEF should not only reflect the need to reduce energy use by counting primary energy, but also recognising the role of electricity in improving 'emissions efficiency'[34]. As the EU has set a clear direction for the decarbonisation of its power sector, WindEurope supports a 'desired' PEF value that reflects this development. The PEF for non-combustible renewables should be lower than 1.

Furthermore, WindEurope supports a dynamic approach to the PEF ensuring it triggers the use of electricity where and when[35] it is the more efficient option. This means allowing Member States to use the European or a national PEF, whichever value is the lowest, when implementing the EED and EPBD. However, eco-design and energy labelling regulations should apply a uniform value for the entire EU

[33] The previous regulation stipulated a PEF of 2.5

[34] Keith Dennis, et al, 2016. Environmentally beneficial electrification. The electricity journal. Volume 29, Issue 6, p.52-56

[35] If an efficiency measure reduces power consumption in hours of high demand, renewable energies and base load power plants will continue to produce and only the peak load plants (mostly gas and oil turbines) will adjust their power generation accordingly. While the average generation mix is easy to estimate, determining the marginal generation unit however requires more complex assumptions. European Commission (2016)

market[36] based on the annex IV of EED. Moving away from static PEF value that are set in stone for several years to a more frequent review of these values based on annual or even seasonal average.

INCENTIVES FOR THE WIDESPREAD USE OF HEAT PUMPS

Buildings account for 40% of Europe's energy consumption and two-thirds of Europe's buildings were built before energy performance standards were set up. Emissions from residential and commercial buildings must reduce significantly to achieve net-zero emissions by 2050.

The breakthrough should come from cooking, space heating and water heating, currently dominated by fossil-based gas. Appliances, lighting and space cooling are already generally electrified[37]. **The use of electric heat pumps could deliver the breakthrough in space and water heating.**

Heat pumps have a high coefficient of performance. They provide about three times more thermal energy than the electricity they consume. Although they represent only 2% of the final energy demand for heating and cooling today, they are quickly spreading. The heat pumps stock at the end of 2017 exceeded 10.6 million units and, with a current annual market above 1 million units, their contribution could increase significantly in the next decade.

Particularly **heat pumps used in district heating networks** – which generate heat in central plants and pump hot water into homes via underground networks – **will play a central role in driving the electrification in residential buildings.** District heating accounts for just 9% of space and hot water heating in the European Union. These networks are mainly used in the energy systems in the Nordic countries and Germany. Switching these networks to use heat pumps instead of fossil fuels would tap into the increasing demand for heating in fast-growing cities.

Member States should incentivise the use of heat pumps in residential and commercial buildings by providing investment support for retrofitting installations, tax breaks and other economic incentives. Crucially local authorities developing new residential and commercial areas should consider as the first choice for heating buildings district heating networks with heat pumps.

In industry, high temperature heat pumps could also deliver energy savings and emissions reduction[38]. Applications exist across process cooling, air-conditioning, heating, drying and distillation in several industries, like chemicals manufacturing, food processing, textiles and printing.

INCENTIVES FOR ELECTRIC VEHICLES

Tax incentives for electric vehicles (EVs) and charging infrastructure deployment are key to accelerate the electrification of the transport. On one hand, incentives like tax credits can increase the attractiveness of investing in charging infrastructure by reducing upfront costs for residential and

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[36] It would otherwise limit the free movement of goods and services in the Single Market. The calculation of energy efficiency of products is to be specified directly in the products' regulations. For instance, the energy efficiency of electrical devices such as heat pumps is calculated as the seasonal coefficient of performance divided by the PEF, with specific corrections.

[37] The implementation of the Energy Performance of Buildings Directive (EPBD) agreed in May 2018 could have a significant impact in energy efficiency policies across countries.

[38] Applications of industrial heat pumps. IEA Industrial energy-related systems and technologies Annex 13. IEA Heat Pump Programme Annex 35. https://iea-industry.org/app/uploads/annex-xiii-part-d.pdf

commercial consumers. Public charging infrastructure should also benefit from this. And green procurement for public fleets can also help cities decarbonise their public vehicles.

Investment or production tax credits rewarding vehicle charging with renewable electricity, similar to the tax credits for renewable energy, could also be used for charging infrastructure.

However, in order to have a significant impact, these **measures should go beyond the financial aspect** and reshape the transport sector. Monetary and non-monetary incentives such as preferential access to urban areas, access to high occupancy vehicle (HOV) lanes, discounts or waivers on registration, reduced annual taxes, and free parking or electricity tariffs adequate to incentivise EV use are some of the examples. Moreover, the promotion of car-sharing schemes and electric two- and three-wheelers as well as the support for non-passenger modes such as fleet vehicles should be prioritised.

4.2 HYDROGEN TAXONOMY

There is no commonly agreed definition and classification for hydrogen at EU-level. The terminology surrounding this potential solution for decarbonising Europe's hard-to-abate sectors can be confusing and potentially misleading.

The regulatory definition and classification given to hydrogen, and especially renewable hydrogen, will be crucial to determine its role in the decarbonisation of the energy system and cross-vector integration[39]. And it will determine hydrogen's treatment in the European Commission's State Aid Guidelines for Environmental Protection and Energy.

There are multiple routes for producing hydrogen which involve varying levels of CO_2 emissions and environmental impacts. Such emissions are mainly determined by the process and the feedstock used in the production. The taxonomy and criteria for hydrogen should unambiguously define these different sources and routes.

WindEurope calls for a clear, simple and transparent classification for renewable hydrogen and hydrogen-derivatives in which the electrolysed hydrogen powered by 100% zero-carbon renewable electricity is the reference baseline, avoiding complex definitions to maintain a reliable, trust and integrity information for people.

The recast Renewable Energy Directive (EU Directive 2018/2001) defines what renewable energy or renewable sources are but it does not define clearly whether other energy carriers produced with such renewable energy or sources can be referred to as renewables when used in other sectors, for example when used industry feedstock[40]. The only case foreseen in the Directive is for the transport sector[41]. Article 2(36) states:

[39] The recent 32th Regulatory Forum for Gas (the Madrid Forum) discussed further the definition for renewable hydrogen without reaching any conclusion. It is expected that the European Commission and stakeholders come together again in October 2019 to continue the discussions.

[40] Article 2(1) states that 'energy from renewable sources' or 'renewable energy' means energy from renewable non-fossil sources, namely wind, solar (solar thermal and solar photovoltaic) and geothermal energy, ambient energy, tide, wave and other ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas, and biogas.

[41] This definition is also used in the EU Alternative Fuel Infrastructure Directive (2014/94/EU) and the Fuels Quality Directive.

"'renewable liquid and gaseous transport fuels of non-biological origin' means liquid or gaseous fuels which are used in the transport sector other than biofuels or biogas, the energy content of which is derived from renewable sources other than biomass."

Specifically, the definition of hydrogen will determine how the calculation of the fuel supplier obligation in Article 25 of the Renewable Energy Directive should be done. This is the main provision in the Directive to mainstreaming renewable energy in the transport sector. It establishes targets for the use of advanced biofuels including renewable liquid and gaseous transport fuels of non-biological origin (i.e. hydrogen). And it proposes strict accounting methods for demonstrations compliance (see annex I).

Furthermore, the Directive contains provisions for the establishment of Guarantees of Origin schemes that will include hydrogen. Article 25.2 requires that the greenhouse gas emission savings from the use of renewable liquid and gaseous transport fuels of non-biological origin excluding recycled carbon fuels shall be at least 70% as of 1 January 2021.

However, the provisions included in the Directive are straightforward to account for onsite hydrogen production in a closed-looped system. But **when electrolysers are connected to a power grid with a varied energy mix and co-located with other sources of power generation, other approaches to account and trace the origin of electricity are needed**. This is necessary as regulation requires to prove the origin of hydrogen (and other fuels) i.e., fossil vs electricity origin, and, if electricity, RES or non-RES electricity used.

European Commission will develop a methodology to better account for the share of renewable electricity used in produced hydrogen with equipment connected to the grid. It is planned that it will adopt a delegated act by 31 December 2021 to supplement the Renewable Energy Directive.

4.3 TRACEABILITY OF HYDROGEN - GUARANTEES OF ORIGIN

The classification of hydrogen will determine the type and amount of Guarantees of Origin (GOs) given to hydrogen producers when using renewable energy. The Fuels Quality Directive does not have, neither binding, nor voluntarily certification of origin system at European level.

However, the REDII foresees that GOs should be extended to cover renewable gas (biomethane) including renewable hydrogen (Art. 19.7). And crucially it leaves to the **Member States the option of extending GOs to energy from non-renewable sources, arguing that it would enable the creation of GOs for hydrogen** (see Annex 1 for more info).

The purpose of Guarantees of Origin (GOs) for renewable gases, as set in the Renewable Energy Directive, should be restricted to "transparency" measure for end-consumers to guarantee the renewable origin (e.g., allow for demand opting for a renewable energy supply in a trustworthy manner), but not to introduce a "green certificate support" scheme (e.g., implementation of a renewables quota scheme).

Guarantees of Origin for renewable energy play an important role to stimulate final customer's demand for renewable energy and thus will contribute significantly to achieve renewable targets while reducing consumer costs. They can represent a value for the renewable industry in the future especially with the uptake of corporate PPAs. In order to preserve this value, a clear distinction must be ensured between GOs for renewable energy (electricity and hydrogen) and, where applicable - GOs for non-renewable energies. Renewable energy GOs should only be issued for energies that are 100% renewable-based.

4.4 ROLES AND RESPONSIBILITIES OF REGULATED AND MARKET PLAYERS

If hydrogen is to play a larger role in sector coupling, **policy makers should clarify regulations in the energy sector with regards to ownership, production, and storage of hydrogen facilities**. It should also set a legal framework covering the following areas[42]:

- Gas grid network access;
- A framework for permission to connect to the gas grid and inject/blend hydrogen into the grid;
- A financial/payments and billing regime receipt, transport and supply of hydrogen or hydrogen rich natural gas meeting quality requirements to customers;
- Safety regimes for temporary hydrogen storage facilities, and the connection, blending and injection of hydrogen to the gas grid – along with safety regimes for domestic, commercial and other end-used equipment connected to the gas grid.

The latest Regulatory Forum for Gas (the Madrid Forum) discussed two approaches related to ownership of hydrogen facilities context of sector coupling:

1. One approach defines these activities as a “conversion” service and not an energy production facility, and therefore believe that they should be perceived as a natural monopoly.
2. A second approach is that it is necessary to get the first investments to enable power-to-gas business cases for investors: public funding for financial R&D support should be envisaged, while industrial consortia can play a key role. Once mature and commercially available, power-to-gas technologies are in principle commercial activities which cannot be carried out by regulated entities.

However, **Power-to-Gas should not be understood as a “conversion” activity/asset** (i.e. unbundled from both renewable power production and CH_4/H_2 storage activities/assets) and it is not a natural monopoly:

- According to widely accepted microeconomic principles, a natural monopoly exists when there are large economies of scale in relation to the size of the market – i.e. when the total cost of the system with several competing suppliers is greater than with a single supplier due to the economies of scale the latter can achieve. In the power sector, this is the case of networks.
- With regard to Power-to-Gas, it is not clear at all (a) whether significant economies of scale exist, and (b) whether those economies of scale are large in relation to the size of the gas (CH_4, H_2) market. No robust evidence has been presented so far and, in any case, all the data available points indeed to a competitive activity (e.g. unit cost functions largely independent on size; both CH_4 and H_2 markets are really large). As a reference, consider the case of Gas-to-Power, which clearly lacks the characteristics of a natural monopoly. However, and according to the first

[42] https://www.hylaw.eu/sites/default/files/2019-06/EU%20Policy%20Paper%20%28June%202019%29.pdf

approach terminology, Gas-to-Power would be performing also a "conversion", although under market-based conditions.

- Therefore, there is no fundamental reason to regulate this "conversion" activity and, hence, grant any role to TSOs/DSOs. In this sense, it is fundamental to unbundle Power-to-Gas from renewable power production (potentially feeding the Power-to-Gas facility) and gas storage (the gas produced could be later injected into a storage). Power-to-Gas must be assessed as an independent part of the supply chain, similarly to any other asset (e.g. Gas-to-Power assessed independently from the Power-to-gas and / or gas storage upstream and the electricity storage downstream). Otherwise, it would be a breach of the unbundling principle rooted in the early days of liberalisation. For the sake of non-discrimination Power-to-Gas should in any case be treated the same as Gas-to-Power, as both are competitive activities and sector coupling technologies.

TSOs/DSOs should not be involved in competitive activities like Power-to-Gas, as they will have a potential conflict of interest when planning, granting access and operating / dispatching infrastructures, i.e. the effective separation of networks from activities of production and supply is a fundamental pillar for achieving the objective of a well-functioning energy market.

The same principles and conditions defined in the Clean Energy Package for allowing TSOs/DSOs to own, develop, manage or operate electricity storage facilities should be applied to P2X (regardless whether eventually in the hands of electricity or gas TSOs/DSOs). This would indeed ensure a level-playing-field between electricity and gas and, hence, an efficient sector coupling.

The new Electricity Directive (Directive 2019/944) reinforces the fundamental concept that network operators should not own, develop, manage or operate assets corresponding to competitive activities. These activities should be subject to competition as the most cost-efficient way to meet customer demands.

However, with regard to energy storage in hands of TSOs/DSOs, the exemption introduced in Articles 36 & 54 of that Directive 2019/944, allows Member States to apply certain derogations. These should not be incorrectly considered as regulatory precedents for Power-to-Gas:

- First, if a number of conditions are fulfilled – e.g. lack of market interest, regulatory authority granting its approval. More specifically, among those conditions is that those storages "*are not used to buy or sell electricity in the electricity markets*". This means that the services those storages are allowed to provide are restricted to the efficient, reliable and secure operation of the system – i.e. no possibility for a "*storage service*".
- Second, if these facilities are "*fully integrated network components*" – i.e. "*network components that… are used for the only purpose of ensuring a secure and reliable operation of the transmission or distribution system but not for balancing nor congestion management*". Once, again no possibility for a "*storage service*".

WindEurope calls for a regulatory framework for sector coupling in which energy generation, conversion, storage, transmission and distribution are unbundled and market players, not regulated entities like TSOs and DSOs, drive the development and operation of assets.

In the context of cross-vector integration, hydrogen producers are subject to legislation under the chemicals and industrial sectors at EU-level, not as part of the energy regulatory framework[43]. The different sources and feedstock to produce hydrogen are not taken into consideration in these regulations. For example, the Emissions Directive[44] makes no distinction between the different types of hydrogen production and it subjects renewable-based hydrogen to the same requirements as other emitting industrial processes, even for small quantities of production.

Also, the regulatory framework for hydrogen production and storage varies per country. Hydrogen is regarded and treated as an industrial gas that can only be produced in zones destined to industrial activity[45], irrespective of the different production methods.

Policy makers should modify regulations recognising the different hydrogen production methods. Particularly, renewable-based hydrogen should not be relegated to only industrial zones and treated as other emitting industrial processes.

4.5 ROLES AND RESPONSIBILITIES IN INFRASTRUCTURE DEVELOPMENT FOR SECTOR COUPLING

POWER GRIDS

Further development of the power grid infrastructure is a 'no regret' option. Increasing the electricity share in Europe's energy mix would require larger and stronger grids. An estimated average of 12,000 GW-km/year of additional power lines would be needed to 2050[46]. This is in stark contrast to what Europe has been building in the last 10 years, but is comparable to the rate of deployment in the 90s and early 2000s.

At European level, the ENTSO-E Ten-Year Network Development Plan (TYNYP) is the master plan for grid development. It aims to coordinate electricity system planning across 43 TSOs. In its 2018 version it foresees up to €114bn (€10.4bn/year) of investments for grid infrastructure to 2030. **The level of grid investment envisaged by the European Commission decarbonisation strategy is up to 10 times higher than that** over the 2031-2050 period. ENTSO-E modelling results are based on a 40-59 GW of offshore wind by 2030 and a maximum of 127 GW by 2040.

While the existing power grid should be optimised, the EU and Member States should also step up the grid build out significantly. The upcoming TEN-E Regulation revision in 2020 should be aligned towards a renewables-based electrification and prioritise electricity infrastructure.

[43] The key requirements for hydrogen production can be traced back to three main EU Directives which establish the general obligations on operators and manufacturers of equipment: The SEVESO Directive (2012/18/EU) and The ATEX Directive (2014/34/EU)

[44] Directive 2010/75/EU on Industrial Emissions

[45] NACE code: 20.11 – Manufacture of industrial gases.

[46] WindEurope 2018, Breaking new ground

TRANSMISSION GAS NETWORKS

The EU's fossil gas demand is set to decrease under all future decarbonisation scenarios to 2050. If Europe is to become carbon neutral, fossil gas would pass from around 20% of final energy consumption in 2030 to less than 5% in 2050[47].

Gas TSOs have currently more spare capacity in their networks than electricity TSOs. **This raises questions about to what extent the existing gas transmission infrastructure will be needed, how this spare capacity can be used, and whether Europe should invest in further expansion or adaption of the gas grid for other non-fossil, zero-carbon gases.**

WindEurope believes that the role of the European gas infrastructure would be to enable the decarbonisation only where direct electrification is not possible. In such scenario, it is inevitable that many gas assets would have to be decommissioned and the overall infrastructure downsized accordingly in order to keep the economic fundamentals. A major risk is to keep assets operational for too long locking-in economies with energy carriers with high carbon content. This is especially the case for gas generation assets which could become stranded overnight.

There are 2.2 million kilometres of gas pipelines available in Europe, with an underground storage capacity of 1,200 TWh. This is enough to cover today's EU average gas demand for more than three months[48]. Its size, spread, long operational life, and the historical investments (in order of billions of euros) are some of the reasons why cross-vector integration is seen as an important strategy for the future by some.

The potential substitution of fossil gas for hydrogen, biogas and bio-methane is frequently put forward as a sustainable approach in order to keep investing in pipelines, but its large scale implementation is far from secure.

In reality, biogas consumption is better adapted for local use, where the availability of bio-waste and residues may be economically viable for energy generation. Large-scale centralised production and long-mileage transportation should not be pursued. In addition, there are limited facilities in Europe to upgrade biogas into biomethane and make it suitable to be injected in the existing pipelines. The geography of the demand therefore makes the current infrastructure poorly adapted to these renewable gases.

But **if Europe is to produce, import and consume hydrogen from renewable electricity in considerable amounts, some infrastructure development could be required depending on the end use**. Hydrogen used as feedstock for industry is a high value gas that is needed in pure form. Today most of it is compressed and transported by trucks or used at the site of production. While transporting and storing hydrogen could be done in the existing gas pipelines, the switch from gas to hydrogen is not a clean cut. There is the need to test and demonstrate the safe and reliable storage and transport of hydrogen across large distances and over long timeframes.

Given the significant uncertainties on the evolution of the demand for gas in the long run and due to the still incipient phase of cross-vector integration technologies new investment decisions on gas

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[47] European Commission, 2018. In depth analysis in support of the Commission Communication COM 2018)773. A Clean Planet for All. A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy.

[48] Hydrogen Europe, 2019. Hydrogen Europe vision on the role of hydrogen and gas infrastructure on the road toward a climate neutral economy.

infrastructure should be carefully assessed, a stronger oversight by the Agency for the Cooperation of Energy Regulators (ACER) and National Regulatory Authorities (NRAs) will be necessary and the increasing importance of links between gas and electricity infrastructure shall be reflected in a new requirement for joint grid planning activities, at both European and national levels.

Policy should assess rigorously the extent of the benefits and speed to implement the uses of the gas infrastructure for providing flexibility to the energy system. And it should do it in light of the existence of other sources of flexibility available such as demand response, power grids and other long-term seasonal storage technologies.

CHARGING INFRASTRUCTURE

A reliable and comprehensive coverage of charging infrastructure for all vehicles (cars, vans, trucks and buses) **is a prerequisite for the transition to a decarbonised road transport sector**. It provides certainty for electric vehicle users and potential adopters, as well as for transport operators and authorities willing to deploy electric heavy-duty vehicles.

Europe should prioritise the deployment of public charging (regular power charging in urban areas or high power charging along corridors). This could account for at least to about 20% of passenger car charging, while the majority of charging could be done with private chargers in buildings (at home or at work). Public charging points in highways will require focus on fast-charging infrastructure.

Infrastructure development both in public and private points will need to incorporate smart meters and focus on smart charging methods to accommodate the increased needs of flexibility.

Last, hydrogen refuelling infrastructure needs to be developed to accommodate fuel cell vehicles in for the heavy-duty segment.

ANNEX I

HYDROGEN-RELATED PROVISIONS IN THE RENEWABLE ENERGY DIRECTIVE

TAXONOMY

The definition and taxonomy of hydrogen will determine how the calculation of the fuel supplier obligation in Article 25 of the Renewable Energy Directive II (REDII) should be done. This is the main provision in the Directive to mainstreaming renewable energy in the transport sector. It establishes that Member States must ensure that the share of renewables in transport is at least 14% by 2030 (up from around 8% today) including renewable liquid and gaseous transport fuels of non-biological origin (i.e. hydrogen). These non-biological origin fuels should be accounted for also when they are used as intermediate products for the production of conventional fuels.

Article 27 of the Directive establishes the parameters in order to calculate and demonstrate compliance with the minimum shares referred to in Article 25.

Article 27 has detailed provisions favouring the use renewable electricity in transport over biofuels and biogas. It assigns to renewable electricity four times its energy content when supplied to road transport and 1.5 when supplied to rail transport [2 (b)], against twice the value for biogas and biofuels.

Furthermore, in order to ensure demand for electricity in the transport sector goes beyond the current baseline and it is met with additional renewable energy generation capacity, *the Commission shall develop a framework on additionality in the transport sector and shall develop different options with a view to determining the baseline of Member States and measuring additionality [3]*.

The additionality aspect suggests that the intention of the legislation is to ensure that current renewable electricity installations are kept accounted for in the power sector, instead of in the transport sector. In other words, in order to maintain the decarbonisation trajectory in the power sector and kick-start it in transport, additional renewable electricity installations should be installed.

However, this additionality aspect is also interpreted by fuel producers as an excessive burden in order to decarbonise their products through renewable-based hydrogen. In their view the European Commission should not impose adding more renewable electricity capacity in order to be able to produce hydrogen. This would only incentivise to do it with fossil fuels and CCS, or to do it with low carbon (i.e. biomass-based) hydrogen.

Furthermore, the Directive establishes that in order to determine the amount of renewable electricity used in fuels [...] *Member States should refer to the two year-period before in which the electricity is supplied in its territory* [3], with the exception when there is a direct connection to an installation generating renewable electricity supplying to road transport. In this case it should be counted as fully renewable. This rule also applies where electricity is used for the production of renewable liquid and gaseous transport fuels of non-biological origin, either directly or for the production of intermediate products.

This means that if fuel producers would end up paying for the build out of more renewable electricity capacity, they will have not only the issue of finding a good location for such projects, but also the risk that this may not be fully taken into account until after two years unless they install the project with a direct connection to the electrolyser.

In many cases it will be challenging to put an electrolyser next to a wind or solar farm due to lack of space or suboptimal location in terms of renewable resources. Moreover without back-up from the electricity grid, operating hours of electrolysers will be too low to be profitable. A legal framework/methodology needs to be designed to make it possible to operate grid-connected electrolysers with 100 % renewable electricity e.g. based on a PPA with one or more renewable installations. This is already foreseen in REDII and needs to be specified in a delegated act (Art. 25.3 last two subparagraphs).

This barrier is very important for very large refineries to comply with the fuel suppliers' obligation with non-biological origin gases or liquids. In general refineries have high electricity prices but relatively low feedstock prices (fossil gas), making the case for renewable-based hydrogen very challenging.

The issue is even worse if hydrogen producers opt for a combination of grid-connected electrolyser (which will be subject to the energy mix from the country with two years delay), and onsite renewable electricity generation. There will be one part of renewable electricity that will be rightly accounted for (the one that is directly connected) and one that will be with a two year delay (the one connected to the grid) and which they would probably had paid for to demonstrate additionality.

The REDII Art 27, paragraph 3, is explicit about allowing direct and grid-connected by stating that [...] *electricity obtained from direct connection to an installation generating renewable electricity may be fully counted as renewable electricity where it is used for the production of renewable liquid and gaseous transport fuels of non-biological origin, provided that the installation:*

> *(a) comes into operation after, or at the same time as, the installation producing the renewable liquid and gaseous transport fuels of non-biological origin; and*
>
> *(b) is not connected to the grid or is connected to the grid but evidence can be provided that the electricity concerned has been supplied without taking electricity from the grid.*

Electricity that has been taken from the grid may be counted as fully renewable provided that it is produced exclusively from renewable sources and the renewable properties and other appropriate criteria have been demonstrated, ensuring that the renewable properties of that electricity are claimed only once and only in one end-use sector.

Last, it states that the European Commission will develop a methodology to better account for the share of renewable electricity used in produced hydrogen with equipment connected to the grid. It is planned that it will adopt a delegated act by 31 December 2021 to supplement the REDII which will include detailed rules by which economic operators are to comply with the Art. 25 and 27 (para. 3, 5 and 6 subparagraphs). We understand that this methodology is already in the making and that the European Commission has set an expert group to come up with proposals.

GUARANTEES OF ORIGIN

The REDII foresees that GOs should be extended to cover renewable gas (biomethane) including renewable hydrogen. And crucially it leaves to the Member States the option of extending GOs to energy from non-renewable sources, arguing that it would enable the creation of GOs for hydrogen.

> *(59) Guarantees of origin which are currently in place for renewable electricity should be extended to cover renewable gas.* ***Extending the Guarantees of Origin system to energy from non-renewable sources should be an option for Member States.*** *This would provide a consistent means of proving to final customers the origin of renewable gas such as biomethane and would facilitate greater cross-border trade in such gas. It would also enable the creation of Guarantees of Origin for other renewable gas such as hydrogen.*

There are important aspects to consider for the creation of a GO scheme for hydrogen. First, the type and origin of the gas (taxonomy), second is to create a system for generating GOs auditing, tracking and exchanging them, and third it is needed to create a market place to bring together producers and consumers. Issues around these aspects are:

- Which types of hydrogen should receive GOs? All, some, or only one type? Should this be producers or consumers decision?
- Who should design the GO system? Should it be private market-based or government driven system? Once in place, should it be voluntary or compulsory to participate in the system?
- When GOs are exchanged between carriers, how the system ensures there is no double counting?
- Should the GOs have a value in the market?

The REDII establishes:

> *(55) Guarantees of Origin issued for the purposes of this Directive have the sole function of showing to a final customer that a given share or quantity of energy was produced from renewable sources. A Guarantee of Origin can be transferred, independently of the energy to which it relates, from one holder to another. However, with a view to ensuring that a unit of renewable energy is disclosed to a customer only once, double counting and double disclosure of Guarantees of Origin should be avoided. Energy from renewable sources in relation to which the accompanying Guarantee of Origin has been sold separately by the producer should not be disclosed or sold to the final customer as energy from renewable sources. It is important to distinguish between green certificates used for support schemes and Guarantees of Origin.*

The first two sentences from the paragraph above are very straightforward to interpret. These mean that the Directive allows the transfer of GOs from one holder to another, but the renewable energy of which the GO refers to must be disclosed only once to a consumer. The third sentence sates that if a producer has sold separately renewable energy from a GO, this energy should not be disclosed or sold to the final consumer as renewable. This means that only the consumer that possess the GO is able to claim its energy as renewable.