European University Institute

ROBERT SCHUMAN CENTRE FOR ADVANCED STUDIES

FSR ENERGY
Florence School of Regulation

Issue 2019/16
October 2019

POLICY BRIEF

Energy Priorities for the Von der Leyen Commission

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Highlights

- The next European Commission's energy policy should be based on six key foundations, able to ensure the achievement of the 2030 targets and to put the EU on a stable path to full decarbonisation by 2050, while also providing an engine in terms of jobs and economic growth.
- First, determined action is needed with regards to electricity balancing markets to ensure that the increased level of intermittency in the electricity market does not provide a fundamental break on the development of RES investment.
- Second, "Renewable Energy Apollo Projects" are necessary because the EU will not achieve ist 2030 targets on renewables on a "business as usual" basis.
- Third, we need to ensure we lay the groundwork for a physical electricity grid designed for 2050; that grid will look significantly different from that of today and sustained investment is required.
- Fourth, sector coupling represents one of the greatest challenges for the next Commission. The ETS is the obvious mechanism to drive this change, and the Commission will have to see how to let it fulfil its full potential.
- Firth, new digital technologies will open important new opportunities. A new regulatory framework is needed to ensure that the digital economy, and EVs in particular, can make their full contribution to the EU's decarbonised energy market.
- Sixth, the next Commission will need to provide the regulatory framework and create the investment conditions to enable the decarbonised hydrogen market to emerge and grow.

The following article was prepared in order to provide input by the Florence School of Regulation (FSR) into the Commission's forthcoming deliberations on its detailed Work Program for the next legislature and had been addressed by the Director of the FSR, Jean-Michel Glachant, to President Von der Leyen, EVP Timmermans and Energy Commissioner Simson.

Introduction

We believe that the next Commission will be determinative for the success or failure of European Energy Policy.

Putting the EU fully on track to achieve the full decarbonisation of its energy system by 2050, and achieving the 2030 targets, must be considered the foundation upon which all else is built. We now have the technologies to meet this challenge, although some – such as cost-effective hydrogen production at scale – are still in their infancy. By meeting our 2030 targets, putting us on a path to reach our 2050 goal, creating new technologies and new industries, as well as producing our own energy instead of importing oil, we can become a beacon to the world. If Europe does not play this role, who else will?

Sustainability and decarbonisation, are therefore the foundation of our energy policy, and is an obligation for the EU rather than an option. But it cannot be our sole energy goal. Europe's energy policy, since its inception in the mid-2000's has always had three underlying objectives: (i) sustainability, (ii) security and (iii) competitiveness. We must strive to form an energy policy that is an 'equilateral triangle' of these three objectives.

Since much of the rest of the world are less committed to dealing with the climate crisis, achieving this triangle is difficult. Indeed, decarbonising our energy system will raise prices in the short-to-medium term, but this rise in prices can be limited if we plan ahead, invest wisely, and act with determination to ensure that we reap the benefits – in technology leadership and exports – that will result. The judicious use of trade policy instruments, to protect our jobs, can help this change and push others to act as well.

But we have to face these challenges, and opportunities, with our eyes wide open. We cannot ignore the challenges ahead that we must overcome if we wish to fully decarbonise our energy system. There are many such challenges, and they are far from being solvable merely on the basis of what we know today.

Without strong leadership from the Commission in the next five years, we see a risk that the EU's global leadership in energy policy will falter, as electricity prices rise quicker and more significantly than they must and this, in turn, risks provoking a reduced determination at the national level to push ahead with ambition.

Yet, at the same time, it is becoming evident that current approaches to energy policy and regulation will need to significantly evolve in the next decade to meet new challenges. The foundations for this will need to be laid now, to create the conditions that will drive investment in new technologies.

With this paper, which is built on the findings of the EUI Brussels Energy Conference that took place on September 12th, we seek to identify what we believe are the key priorities for the next Commission, and provide our recommendations for achieving them. We identify **'Six Energy Foundations' for the next Commission.** These are not intended to be exhaustive – as there are many other actions that will also require the Commission's attention – , but, in our view, they represent the most essential priorities.

Achieving the 2030 Energy Efficiency and Renewable Energy Objectives.

With respect to energy efficiency, we can only underline the importance of the 'energy efficiency first' principle. Indeed, simply put, it is the cheapest, most effective and most job-creating manner for the EU to achieve its decarbonisation objectives and, at the same time, to fully address the goals of competitiveness and security of supply.

We note with concern that the Member States' intentions, as laid out in their draft National Energy and Climate Action Plans (NECPs), fail to collectively achieve the 32.5% energy efficiency target. Furthermore, the plans themselves fail to provide any con-

vincing details as to how even their current (lower) level of ambition would be achieved.

This concern is exacerbated by the fact that the EU, overall, is only close to achieving its 2020 target of 20% improved energy efficiency because growth in energy demand was severely reduced, between 2008 and 2014, by the economic crisis, and demand in the Member States has been creeping up ever since.

The 32.5% overall EU energy efficiency target for 2030 looks close to being 'on-track' in terms of Member States' intentions based on the draft NECPs, although additional commitment is needed. However, this is only because of the very ambitious targets sets by some 'outlier' Member States such as Italy (43%) and Spain (39.6%) which, on the basis of the NECPs, look unlikely to be achieved. Furthermore, an examination of all the NECPs demonstrates a lack of transparency – or future planning – by Member States on how they will take the difficult concrete actions necessary to achieve their targets, which, even if less ambitious than Italy or Spain, remain challenging.

We note that the actions that could be characterized as the 'low-hanging fruits' regarding energy efficiency that can be taken at the Community level have already been taken, and achieving results in the future will be determined by the ability of Member States to take often difficult political decisions at the national level. Nonetheless, vigilance, transparency and assisting Member States in achieving their objectives will be essential. Therefore, we strongly welcome the proposals of the Commission to harness the successor of the EFSI to drive energy efficiency projects forwards.

Regarding renewable energy, we congratulate the EU on achieving its 20% target for 2020. The 2030 target of 32% means, according to Commission modelling, that the EU's electricity system will need to be on average 55% provided by renewable energy by 2030, more than 45% of which will come from intermittent sources, notably wind and PV.

However, having read the National Energy and Climate Action Plans of the Member States, and witnessed recent developments on the market, we are concerned that, unless the Commission takes decisive action right at the beginning of its mandate, we will fail to meet both targets.

As mentioned above, since 2014, energy demand has been increasing in most Member States. If demand had increased at this speed between 2008 and 2014, we would not have met our 2020 renewable energy targets without far greater efforts. On current trends, and without action at the Member State level regarding energy efficiency that we fail to see today, we expect energy demand to continue to increase, making the targets far more difficult to achieve. This is an indication of how important action on energy efficiency by the Member States is.

To meet the 2030 renewable energy target, we will have to install the equivalent of 150% of the wind and PV capacity that we will have installed between 2009 and 2020. Yet, we see 'onshore wind fatigue' in many countries and increasing planning constraints. Above all, we note that the Member States' National Energy and Climate Plans do not contain convincing detail on the concrete action that they will take achieve their renewable energy targets.

These factors, combined with the expectation that network costs may rise appreciably from 2025 to deal with the challenge of an increasing level of intermittent power on the grid (meaning price increases for households and industry), give us concern that Member States, no longer obliged to meet legally binding targets, may be tempted to scale down the level of their ambition in the future. This is particularly the case for 'outlier' Member States that have committed to achieve more than their 'fair share' of the overall 32% EU objective.

Specifically regarding network costs, we see the issue of balancing the grid becoming increasingly critical as we move towards the second half of the next decade.

Germany had 36.2% renewable electricity on average at the end of 2017, but already in May 2018, it produced more than 100% of its electricity requirements for the first time. This is now becoming a more common occurrence, and Germany currently solves the problem by exporting the excess electricity, principally to Poland and the Benelux.

On the basis of the National Energy and Climate Action plans, we can expect that renewable electricity will cover the following share of electricity consumption by 2030:

- Belgium, 40.4%;
- Denmark greater than 100%;
- France: 40%;
- Germany 65%;
- Italy: 55.4%,
- Netherlands: 66%,
- Portugal: 80%; and
- Spain: 74%.

Given the minimum trajectory required in meeting these targets – contained in the Governance Regulation – and assuming that Member States succeed in meeting their 2030 RES targets, between 2025 and 2030, we can expect that the whole region of Central Western Europe and Iberia, as well as Italy, will have an increasing number of days when PV and wind production will significantly exceed 100% of demand and, this, probably for sustained periods.

Since whole regions of the EU (rather than just individual countries) will most likely be collectively in excess RES production compared to demand during periods where sun and wind are plentiful, it will no longer be possible to export the electricity to neighbouring countries, although such exports this may provide a partial solution for a limited period in Central Western Europe. Exports will not, however, solve the issue for Iberia or Italy, even in the short term.

In any event, it is clear that, as time progresses, more regions of the EU will have production surplus – above peak demand – from intermittent RES production, and for increasing periods. As we move towards 2030 and beyond, this is likely to be systemic, and increasingly significant.

On the basis of currently foreseeable technology, there are limited options to deal with this 'RES Peak' issue: (i) demand response (increasing consumer demand at specific times), (ii) battery storage (currently expensive; car battery usage will be crucial here [see below]), (iii) hydrogen, produced by electrolysis (currently expensive, even using very low-cost, otherwise curtailed electricity), (iv) pumped hydro storage, and (v) curtailment.

Leaving aside curtailment, it is clear that all the options aside from demand response (which will be limited, as it is difficult to increase energy demand, even with lower prices), pumped storage, and EV daily storage (when we have sufficient EVs and appropriate regulatory framework – see below), will add very significant costs to the system, once peak RES becomes a regular, and important seasonal feature of EU electricity markets.

Furthermore, investment signals are not yet in place to merit investment in hydrogen storage. These signals currently exist only to a limited extent regarding large-scale battery storage, but there risks to be a disincentive to be the first investor because of the expected reductions in cost in this technology. Therefore, there is a very real chance that there will be a shortage of cost-effective storage solutions by the mid-to late 2020s.

If storage solutions are not available, and are not sufficiently competitive, then the most cost-effective solution will be curtailment. However, if, already in the mid-to late 2020s, we see widespread curtailment at peak times, and peak times become an ever more

commonplace event, the logic of further increasing the level of intermittent RES from that point onwards becomes an ever decreasingly valuable proposition.

Thus, if electricity storage, capable of dealing with both daily and seasonable imbalances and sufficiently competitive to the alternative of curtailment, is not in place by the mid-2020s (and thereafter increases to meet demand), growth in RES electricity will likely falter.

This is an issue that needs to be addressed today, and determined action to deal with this already now should be the **first Energy Foundation for the next Commission**.

Investment in R&D to bring down the cost of hydrogen and battery storage will be essential, guaranteeing that the EU is at the forefront of technological development in this area so that we reap the industrial benefits from our leadership in dealing with the climate crisis.

The use of storage from electric vehicles (EVs) will almost certainly be the cheapest manner to deal with daily imbalances, and the Commission needs to ensure that the necessary regulatory framework is in place for its rapid introduction and, where necessary, support this development through research funding (see below).

Building pumped storage is one of the most long-term cost-effective ways of providing balancing, but their lag times and amortization periods are long. Furthermore, capital investment costs are high and revenue guarantee schemes (but probably not subsidies) will therefore be needed to attract investment, and will need to be adapted to purpose, notably with respect to the required duration of support. Sustained efforts will be needed by the Commission and Member States to explain to citizens why new reservoirs are needed to meet the challenge of decarbonising our energy system in an affordable and clean manner, thereby facilitating the relevant planning procedures.

We believe that the Commission should consider a specific initiative covering all of these issues. Without an appropriate regulatory and support framework in place in the near term, there is an evident risk that the growth in renewable energy investment will falter in the latter part of the next decade. Therefore, action is urgent now.

In order to ensure that concrete RES investments follow ambitious targets, the Commission has underlined in its recommendations on the National Energy and Climate Plans the need for concrete, transparent, stable and long-term predictable renewable energy commitments and programs by the Member States. It is vital that this is delivered.

However, it is very clear that we will not achieve this new 2030 ambitious target using a 'business as usual' model, Unless the EU harnesses some of its great renewable energy assets, and above all offshore wind, we fear that we will not meet our 2030 goals, nor lay the foundations for their continued growth to 2050. A piecemeal approach, relying on hundreds of thousands of small projects, will not get us there.

Two of our most valuable renewable energy assets lie in the Far North Sea and the Baltic Sea. We have the capacity, in these areas, to produce a huge part of the energy required to meet our 2030 targets and then develop them further to provide the cheap renewable power we will need for a fully decarbonised system in 2050.

But these projects will require determined action if we want them to be achieved cost effectively. They require an integrated approach, bringing together the assets of different Member States in a coordinated, collaborative manner. The Commission has already demonstrated that an integrated approach to the infrastructure necessary to develop the North and Baltic seas – using a 'hub and spoke' type model – will save EU citizens billions of Euros compared to a project-by-project approach. It now needs to deliver on this vision.

Hundreds of billions of Euros will need to be invested in new infrastructure over a 20- to 30-year period, and an entirely new regulatory approach will also need to be developed. Above all, a new integrated offshore electricity network will need to be designed on the basis of efficiency and inter-connectivity, not national boundaries.

These are **the renewable energy Apollo Projects of Europe's energy future and their achievement should be the second of the next Commission's Six Energy Foundations**. But they will not happen on their own.

To deliver them, the EU will collectively need to commit to delivering these projects, developing new forms of cooperation between the Member States and regulators concerned, and using EU infrastructure and innovation funding to de-risk the first steps towards the achievement of these integrated projects. The best way to provide this framework is legislation agreed at EU level, relevant to both the Far North Seas and the Baltic, as well as future meshed grid networks that we cannot predict today. In addition to strong political commitment to getting these projects done, funding through the CEF, the Cross-Border Renewables fund, the ETS Innovation Fund and research funding, combined with a legislative framework dealing with the specific and novel challenges faced by such 'hybrid' projects can lay the foundations for the rapid development of these precious European assets.

Equally, the EU's long-term objectives with respect to renewable electricity will not be met without additional onshore infrastructure.

Spain has a 2030 RES objective of 42% (including 74% renewable electricity), and Portugal has a 47% RES target (including 82% renewable electricity). Yet Iberia's interconnection level with France is one of the EU's lowest. Surely Iberia, with huge PV potential, has the right to participate in Europe's future energy market?

Equally, it will be essential to bring the renewable electricity from the North and Baltic seas to centres of electricity consumption, and provide the possibility for very large scale PV developments in the South to reach demand centres, including those in the North. Whilst underground HVDC cables offer solutions, they are relatively expensive. Realistically, however, they will be an equally important part of the EU's long-term future, and investing now to start the interconnections that we will need in 10 to 20 year time – not least to lower the cost of this technology – must be one of the next Commission's aims. **Ensuring that we lay the foundations for a physical electricity grid designed for 2050 should be the third of the next Commission's Six Energy Foundations.**

Sector Coupling

In our opinion, Sector Coupling represents one of the greatest challenges for the next Commission. If the Commission succeeds in creating a regulatory framework that truly ensures undistorted and transparent sector coupling, it will have put the EU on the path to a decarbonised and cost-effective energy future that will serve as a beacon for other countries to follow.

Sector Coupling in a decarbonised energy market means no more than a legal, regulatory and tax system whereby all energy sources (wind, PV, nuclear for those countries that choose this option, natural gas with CCS…) and energy vectors (hydrogen, biofuels and gases…) compete with one another in an undistorted manner for all sources of energy demand, taking account of any residual carbon content and non-energy socially relevant considerations (such as air pollution, etc).

This is the 'holy grail' of energy policies, as it will ensure a cost-optimal approach, establish reliable energy and ETS prices and thus drive research

and development into the most promising options moving forward.

The EU's 2020 renewable energy targets have been an overall success. They created mass demand for wind and PV at a time when these technologies were far from competitive. Although Europe has paid renewable energy subsidies and increased electricity prices to achieve this, it has been a price worth paying. It has led to the industrialisation of wind and PV, driving research and economies of scale to the point where, correctly situated and regulated, wind and PV are the cheapest sources of energy on the planet today.

Without Europe's bold vision and action, this would not have happened, and certainly not at the breathtaking speed that it has. Renewable technologies would certainly not be seeing the exponential growth rates all across the world that we see today, even in countries hesitant to embrace action to deal with the climate crisis. European citizens should feel proud of what we have already achieved.

We support the 2030 renewable energy targets, but for different reasons than the one for which the 2020 targets were needed. 'Demand push' through targets will have a limited effect in terms of further industrialising production processes and bringing economies of scale, even if this should not be discounted. Rather, the 2030 targets are needed because the ETS is not able today to fulfil its real objective: establishing a truly effective long-term pricing mechanism for carbon and determining which energy source and vector should meet demand.

The ETS does not cover all sectors, and does not legally guarantee that CO2 emissions connected to the ETS system will be reduced to zero by 2050. Therefore, it does not establish the forward prices necessary to push investment into decarbonising the electricity system through the shift to renewable electricity sufficiently quickly, nor justify investments today into the technologies and markets that we will need moving forwards (such as, for example, hydrogen technologies).

Furthermore, current ETS prices are probably too low to catalyse the level of investment in wind and PV, in the short term, that is physically necessary to enable us to meet our 2050 goals, simply in terms of the time, planning and network development required to guarantee a high renewable share by 2050. Renewable electricity will without a doubt form the 'backbone' of our electricity system in 2050, meeting the 'lion's share' of demand. Thus, at least until 2030, the targets are needed to guarantee that the renewable energy capacity is in place by 2030 so that it can act as a 'springboard' that will enable us then to remove the remaining 60% of the carbon from our overall energy system in the remaining twenty years.

However, whilst the targets to 2030 make sense, this regulatory driven approach, whereby targets, not markets, decide upon the EU's future energy mix, cannot be our long-term future.

Already by 2030 the EU will have an average of around 55% of its electricity from renewable sources, and these are intermittent: producing a lot of electricity when the wind blows and the sun shines, but much less so when it does not. As mentioned above, this needs balancing, which will bring important additional costs into the system.

Post 2030, therefore, we will need the market to determine the correct energy balance for Europe. In the long-term, a target driven approach will not be able to determine the correct balance in our decarbonised energy mix between:

1. higher levels of renewable electricity and biomass;
2. nuclear (for those countries that choose to pursue this path);
3. natural gas combined with CCS; and
4. hydrogen produced from renewable electricity or natural gas (where the resultant CO2 is stored through CCS or pyrolysis)

Furthermore, a target-based approach will also not be able to determine the most cost-effective approach to balancing.

This is very important. Whilst we cannot exclude the need for further renewable energy targets in 2040 if the ETS price remains too low to ensure the continued development of the 'springboard to 2050' mentioned above, as a matter of principle, if we take a regulatory approach to this rather than letting the market decide the correct long-term balance between renewable electricity and other net zero-carbon energy sources and vectors, we will stifle innovation and increase cost.

Establishing an effective sector coupling approach is therefore vital; it will need to be the basis of our future energy economy.

However, this is a huge challenge. It will require a wholesale rethink of our approach to energy regulation and taxation. It is not correct to think that sector coupling simply means removing obvious regulatory barriers to hydrogen competing with electricity, and EV and battery storage vs other mechanisms, and dealing with issues such as unbundling of hydrogen networks, important though these issues are.

It means ensuring an undistorted level playing field between these different technologies.

It will require a major reform of regulation with respect to the manner that progressively decarbonised gas competes with renewable energy; this is discussed below, under 'Gas Decarbonisaion'.

However, sector coupling goes far beyond this. Not least it requires rethinking our tax system, and we applaud the intention to revisit the Energy Tax Directive. This change will not be simple under current EU voting rules on tax, but a medium term phased approach, whereby Member States agree to gradually evolve energy taxes towards a non-discriminatory 'sector coupling based' system should be feasible. This could happen over a 15-year period for example, giving ample time to take the difficult political decisions needed to shift tax patterns in a manner that would be imperceptible to citizens and directed towards guaranteeing fair energy prices for citizens and increasing our competitiveness.

This revision will have to address some fundamental issues. For example, we will see electric self-driving cars booming in the coming years. Electricity used in EVs is typically taxed less than petrol or diesel. Taxi drivers pay taxes, the software in self-driving cars do not. Electricity typically attracts both environmental and social charges, other energy sources often do not. The necessary reorientation of taxes and revenues will require difficult political choices, but this change is a fundamental requirement of an efficient decarbonised energy system.

We therefore encourage the Commission to view **Sector Coupling as fourth of the six Energy Foundations** of the next Commission and, at least, start the process that will get us, by 2030, to a non-distorted and transparent energy system that will stand the test of time and drive an efficient energy market of the future.

This will ensure a competitive market, drive innovation and set a model for the rest of the world. We believe that sector coupling will drive innovation in balancing and coupling technologies that we can only imagine today, harnessing the storage power of car batteries and homes. When the EU takes leadership of this, it will create a driver for export services.

The ETS is the obvious mechanism to drive this change, and the Commission will have to see how to let it fulfil its full potential.

The imposition of carbon border taxes requires care, as they can lead to a loss of competitiveness in downstream sectors. For example, if carbon border taxes on steel lead to increased EU steel prices, the competitiveness of our car industry can suffer. However, a willingness to protect our companies from unfair competition from countries not willing to address the climate challenge is a valuable tool that can be

part of the solution in moving progressively towards a truly effective ETS.

The Digital Energy Economy

The EU's energy market will have to look very different by 2030, yet alone 2050. Electric vehicles and batteries in houses will be increasing in importance, and this can make a huge contribution in developing a cheap and efficient approach to balancing the electricity network, by using this storage capacity to help balance intermittent renewables.

The electric vehicle (EV) fleet in Europe has grown fast over the last 5 years, with compound average growth rates of around 80% from 2012–2017. With the new EU targets for RES in transport, we can expect these growth rates to continue.

On this basis, there is every expectation that within a relatively short period, if the legal, regulatory and financial mechanisms are in place, the use of EV battery storage, both from batteries installed in vehicles and 'second life' batteries, can resolve a very significant part of the EU's daily balancing needs in a highly cost-effective manner, and one in which citizens participate and benefit. EV batteries, together with those installed in homes and offices for example, can be used to balance consumption and supply in individual houses with PV panels, but more importantly, collectively, can be used to balance the grid.

Indeed, the 'Smart Charging' of EV batteries can help ensure a positive experience for EV drivers (who have their EV battery charged at the time needed) and, at the same time, help to lower the energy transition cost for society.

However, delivering such a system in practice is a regulatory and technical challenge. Not least because it will require data systems that involve potentially hundreds of millions of balancing actors that will need to be fed into real time balancing systems at the DSO level, together with payment and monitoring systems.

At present, several regulatory barriers exist for 'smart charging' in terms of missing regulation, regulation that prevents (or discriminates) against EV storage, grid charges that hinder the installation of high capacity charging points and tax barriers. Furthermore, regulation differs between EU Member states whereas homogeneity in regulation lowers the costs for companies to work cross-border.

Equally, the smart meters that we are installing in homes enable us to revolutionise the ability of every citizen to participate in our decarbonised energy system of tomorrow. Citizens will develop new forms of participating, from being producers, to suppliers of flexibility services, to joining energy communities that club together to invest in windmills or PV parks.

As already mentioned, balancing the electricity grid will be one of the greatest challenges in developing a cost-effective decarbonised electricity system. To do this we will need to harness the most important forms of cheap balancing; those that use existing assets. Thus, using car batteries for electricity storage on a real-time basis, and IT systems to manage demand in industry and homes and reward flexibility whilst maintaining convenience, will be essential.

The EU's leadership of renewable electricity gives us a unique chance to develop the IT systems and mechanisms that will become the future global standard. Whilst this may seem to be a challenge for tomorrow, the Commission needs to lead this today, ensuring that the existing electricity regulatory framework not only permits such systems, but actually encourages them.

These new regulatory approaches will need to be in place already by the mid-2020s to limit the increasing cost of dealing with peak RES. Where necessary, the Commission needs to use its R&D and Innovation funds to drive forward the necessary innovation and structures that will be required. **Accelerating the development of the digital energy market is the proposed fifth of the Six Energy Foundations.**

We therefore propose that the next Commission adopts a specific package of measures ensuring that the regulatory framework is rapidly in place to ensure that the digital economy – and in this respect the role of EVs in particular – can make their full contribution to the EU's decarbonised energy market.

The Hydrogen Economy

There is no longer any academic debate on whether hydrogen will form part of the EU's decarbonised energy mix.

Electricity is too expensive an option for certain energy intensive industrial processes and looks ill adapted to long-haul transport. Hydrogen will need to play a role here. Depending on cost, and the availability of less expensive options, it is equally likely to play some role in storing peak RES electricity on a seasonal basis. Furthermore, it is likely to play a role in heating buildings (as a complement to heat pumps) and, more widely, in transport. Lastly, and again depending on its cost compared to available alternatives, it may be required as part of the decarbonised electricity mix as a complement to RES electricity. Finally, it may be simply impossible to construct the electricity infrastructure that would be needed for us to source almost all of our energy requirements from renewable electricity.

As explained above, it is the market that will ultimately need to determine the future EU energy balance between, for example, RES electricity, biomass, nuclear and hydrogen, achieved through sector coupling. But at present, there is a 'hydrogen investment paradox'.

Whilst it is clear that the EU will need a great deal of decarbonised carbon by 2050, there is currently no investment case to invest in decarbonised or low-carbon hydrogen via electrolysis (aside perhaps for RES peaking), steam methane reforming combined with CCS, nor pyrolysis (converting natural gas into hydrogen and CO2 in solid carbon that can be used in industrial processes). However, we urgently need to invest in hydrogen at industrial scale to bring down the cost of decarbonised hydrogen, as today it is very expensive and its widespread use in the EU energy system would raise prices to an unacceptable level compared to competitors located in countries failing to deal with the climate crisis.

On the other hand, it will need to form part of any decarbonised energy system. Therefore, if the EU can lead the way in getting costs down through industrialisation, and take leadership of this future global industry, it can have profound long-term benefits for the EU.

Thus, creating a regulatory environment that enables hydrogen to compete equally on the market, establishing standards and guarantees of origin, and investing heavily in research and development represents the **final of the Six Energy Foundations.**

The next Commission will therefore need to provide the regulatory framework and create the investment conditions necessary to enable the decarbonised hydrogen market to emerge and grow, much as it did with renewable electricity. This will need to cover a myriad of different issues to provide a strong long-term framework, and the foundations for sector coupling to work effectively.

It will need to cover Guarantees of Origin that demonstrate the CO2 content of any gas, unbundling rules regarding the hydrogen network that will emerge from the existing gas grid, and gas standardisation issues to enable the grid to adapt to different forms of hydrogen. Equally, it will need to set a framework whereby all forms of low-carbon hydrogen, and later only decarbonised hydrogen, can compete on a level-playing field.

Above all, it will require a commitment of EU research and innovation funding to drive down the cost of hydrogen production at scale. This needs to cover CCS but should equally focus on pyrolysis, which is an emerging and very promising technology, pro-

ducing the valuable industrial by-product of solid graphite. Under the pyrolysis method, hydrogen can be produced close to hydrogen demand where CCS is unavailable. Given public reluctance to storing CO2 on land, pyrolysis looks particularly important for the EU's energy future.

Although the market must decide which form of decarbonised hydrogen is the most competitive, the EU needs to invest now, and heavily, in ensuring that costs decline rapidly. Once again, if the EU does not do this, then who else will? Furthermore, in the long-term, there is every likelihood that this investment will repay itself many times over.

Lastly, the EU needs to decide whether we should already push demand for hydrogen, giving a technology pull to work hand-in-hand with the research funding push. This could be done by legislating for minimum levels of hydrogen to be blended into natural gas, through national hydrogen targets in the context of the energy Governance mechanism, or by taxing grey hydrogen in combination with carbon border taxes. Whilst we agree that these represent interesting options, their potential economic effects need to be considered carefully.

QM-AX-19-016-EN-N

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Robert Schuman Centre for Advanced Studies

The Robert Schuman Centre for Advanced Studies, created in 1992 and directed by Professor Brigid Laffan, aims to develop inter-disciplinary and comparative research on the major issues facing the process of European integration, European societies and Europe's place in 21st century global politics. The Centre is home to a large post-doctoral programme and hosts major research programmes, projects and data sets, in addition to a range of working groups and ad hoc initiatives. The research agenda is organised around a set of core themes and is continuously evolving, reflecting the changing agenda of European integration, the expanding membership of the European Union, developments in Europe's neighbourhood and the wider world.

The Florence School of Regulation

The Florence School of Regulation (FSR) was founded in 2004 as a partnership between the Council of the European Energy Regulators (CEER) and the European University Institute (EUI), and it works closely with the European Commission. The Florence School of Regulation, dealing with the main network industries, has developed a strong core of general regulatory topics and concepts as well as inter-sectoral discussion of regulatory practices and policies.

Complete information on our activities can be found online at: fsr.eui.eu

With the support of the
Erasmus+ Programme
of the European Union

doi:10.2870/734901
ISBN:978-92-9084-737-3
ISSN:2467-4540