FREED
Funding Resources for Innovation
in Energy Enterprise Development

NPA Region Innovation Shared Needs Analysis

An Overview of the EU-28 current Energy Innovation Trends

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Northern Periphery and Arctic Programme
2014–2020

EUROPEAN UNION
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About FREED

FREED (Funding Resources for Innovation in Energy Enterprise Development) is a three year project funded under Interreg's Northern Periphery and Arctic Programme.

The Project will provide SME's in the programme area with the support network required to introduce and develop energy innovations which would otherwise be unavailable to them.

FREED's five step process will:

- Carry out a needs analysis of the types of energy innovations required in the partner region
- Initiate a tender process to generate the necessary technology innovations
- Partner R&D institutions with SME's from the region
- Develop business plans to assist the SME's in delivering the innovation in the region
- Provide a financing service that utilises private investment funds to aid the development of the innovations

The project, which is led by the University of Oulu in Finland, is a collaborative partnership involving private investment firms, R&D institutions, colleges of education and public bodies from Scotland, Northern Ireland, Norway, The United Kingdom, Germany and Ireland.

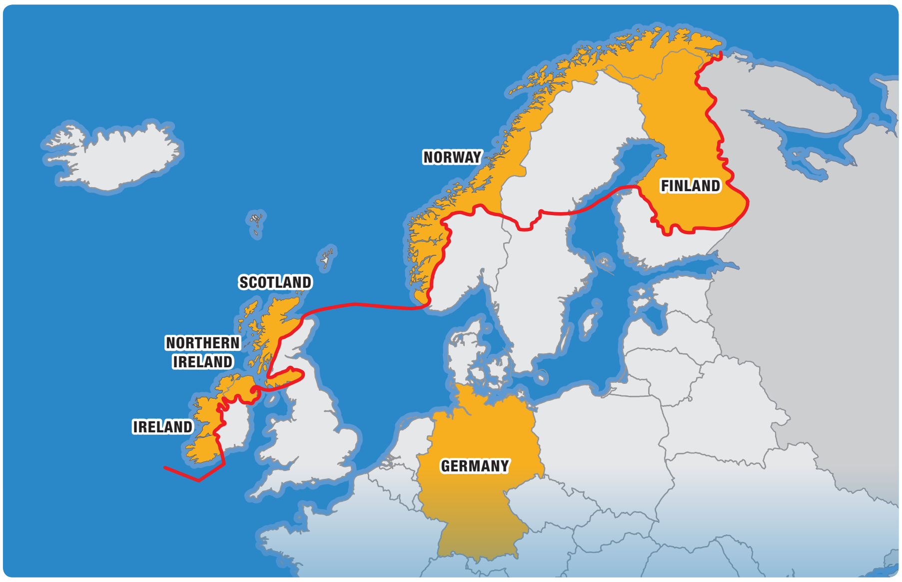
1 Introduction

The member states of the European Union agreed that the percentage of renewable energy sources in the energy mix has to be 20% by 2020. The EU stated the 20/20/20 goals for 2020 including 20% renewable energy, CO_2 reduction and energy efficiency goals.

To achieve this target an even greater portion of the energy mix will have to be renewable with a corresponding increase in energy efficiency, not an easy task but one that can be achieved through energy innovations. This increase in efficiency must be achieved not just within the various energy carriers (electricity, gas, heating) but also in between. To deliver the "20-20-20" climate and energy goals as well as sustainable growth, the European energy system has to innovate rapidly.

The EU energy system has to change in two ways: by cutting down the primary energy demand, and by large scale deployment of renewable energy. The energy transition process is simply a no-brainer for EU member states. Energy transition will create and retain welfare by investments in job creation, countering energy poverty and lowering future energy costs leading to sustainable development and providing the EU with an acceptable climate adaption scenario.

The energy transition process is a complex transition. Currently there are different autonomous developments taking place across member states, each at its own pace and in part, interdependently. The energy landscape that is emerging is one of intermittent sources. These include wind, biomass, solar energy etc. There are also large scale developing technologies such as carbon capture, storage, wave and tidal etc. facing challenging conditions, that will require innovative solutions. The role energy efficiency and micro-renewable advances can provide in the



NPA programme area and participating countries in the Freed project.

challenge should not be underestimated. There are encouraging developments in the field of local energy generation and use. To facilitate these developments, the energy distribution grid must be differently designed as a bi-directional system in which users not only acquire but can also resupply energy. Indeed, energy storage is an area that has taken precedence over the last few years.

Across the EU, the areas of focus for development are summarised as follows:

- Grid infrastructure and capacity
- Smart grid and energy storage
- Energy system integration and coordination
- Sustainable production and use of biomass
- Traffic and transportation
- Establishment and expansion of district heating
- Utilization of waste energy from industry etc.
- Energy savings and efficiency

As referred to previously, regions to a large extent are aiming at the same type of renewable energy resources and are facing similar challenges in the promotion of renewable energy; hence collaboration and knowledge sharing across EU borders in the field of renewable energy technology and innovation are obvious options. EU member states are extremely focused on creating business development in the area of renewable energy and are utilising or planning to utilise business development instruments that in many ways are identical from one region to the other. There appears to be great potential for further cooperation between member states in the efforts to promote renewable energy transition and business development through innovation.

2 The EU Challenge

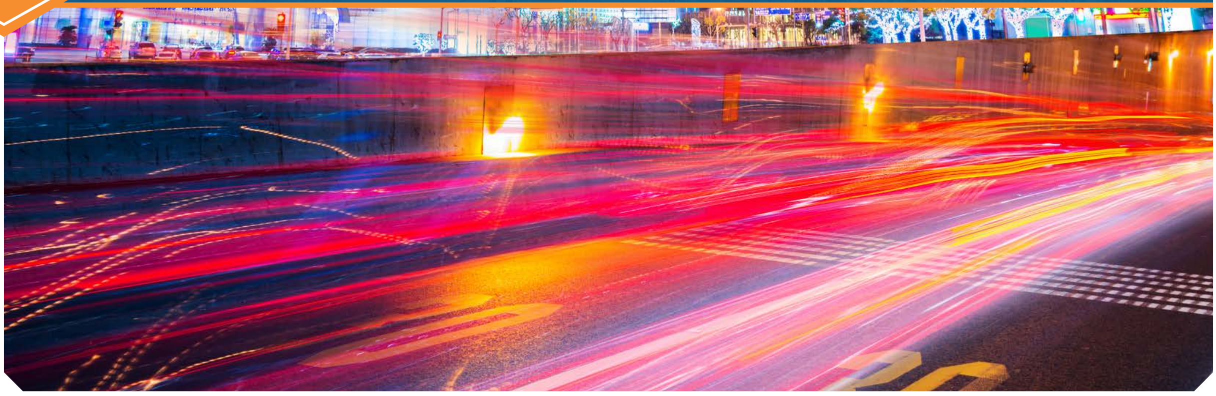
The European Union faces some serious challenges as a result of policy objectives, for example, ensuring a competitive, sustainable energy supply by 2020 and achieving a resource-efficient and low carbon economy by 2050.

Currently, policy trajectories focusing on energy innovations through knowledge exchange are thought to face three key objectives for 2020:

- A 20% reduction in EU greenhouse gas emissions from 1990 levels;
- Raising the share of EU energy consumption produced from renewable resources to 20%;
- A 20% improvement in the EU's energy efficiency.

The use of more durable energy sources, such as renewable energy sources, will play a key part in achieving CO_2 reduction targets. Renewable electricity generation will need to more than double between now and 2020 to meet the EU's 2020 targets. Up to 60% of this new capacity is expected to come from offshore wind turbines, much of these are being and will be installed in the Northern regions of Europe, with the North Sea being a focus of attention. Operating a power network with a high share of renewables will be very different from the way these networks nowadays operate and indeed were designed for. Renewable energy sources create significant challenges to maintaining quality and security of supply, mainly because of their intermittency of output. Managing a rising share of fluctuating renewable energy production through a combination of flexible technologies is the main challenge for energy innovations across the EU member states. This challenge is brought to the fore by demand side management, more use of energy storage, more flexible sustainable generation and more interconnection between networks, which have to meet also social, legal and economic feasibility conditions. Building such an integrated cross border renewable energy system is Europe's challenge in order to succeed in reaching the aforementioned targets. According to the 2014 World Energy Outlook from the International Energy Agency (IEA), Europe is still ahead of the world average in terms of its share of renewable electricity, or installed renewable power. The rest of the world is gradually catching up and investing heavily in new capacity which requires innovation.

3 Regional collaborative contribution to Europe's Challenges



Given its natural assets and technological expertise, most EU member states can strongly contribute to and thereby take a leading role in the required energy shift. There are huge potentials for renewable energy from wind, water movement, solar, biomass, carbon capture and storage etc.

Given the progress in many renewable applications, this together with an European wide integrated energy system could generate a world leading competitive position, which is a prize worth pursuing.

The costs of renewable energy technologies remain high for individual regions and much of this disparity is due to differences in polices. A joint strategy should be considered to boost their development and competitiveness. Strengthening the knowledge transfer between regions could lead to more synergy in the required energy transition and therefore lead to a better integrated cross border EU energy system. Opportunities for Northern Periphery and Arctic regions will present themselves, so, it is not only to make the right decisions with respect to energy innovations that have an impact in these regions but to take advantage of the opportunities to export these also.

The balancing dilemma is complex, since numerous different situations have different pre requisites to be met (political, economic, social, legal and technical aspects). Complex dilemmas can best be tackled by the biggest thinkable group of EU stakeholders. The "triple helix", being the industries, politics and science, are all needed to work on innovation in the energy sector. Coordination of different attempts can contribute to better understanding of the dilemma, from the perspective of the whole value EU energy chain.

4

Policy Can Drive Innovation

As a result of the Fukushima meltdown in 2011, Chancellor Angela Merkel pledged to switch off all nuclear power by 2022 and fill the gap with renewables – a process known as the Energiewende..

As a result of this policy decision there has been a rapid expansion of Germany's offshore wind capacity. While the UK is leading the pack in offshore wind energy with more than 6 GW of installed power, Germany retains its leading European position in terms of total installed capacity in on- and offshore wind energy. Moreover, amendments have been made to seven laws, including the Renewable Energy Sources Act, these amendments continue to provide stable support for onshore wind power and have improved the support framework for offshore wind power.

Within this new political scenario, activities are ramping up in the development and realisation of offshore wind projects off the coast of Northern Germany. The Hamburg region is rapidly developing into one of the key centres for offshore wind development and installation, something ten years ago would have not even been on the radar. Consideration is being given to innovations in foundation concepts, especially that of the "floating device" and operation and management (O & M) in order to bring down installation and operation costs.

The German Government see wind energy as an important technology to help phasing out nuclear, not only in Germany, but worldwide, with German companies embracing the opportunity in the EU and across the globe. As pioneers certainly in the manufacturing of wind turbines and associated equipment, many federal states have benefited from energy policy change. As an example, the process Energiewende has helped to create new industries. About 370,000 Germans now work in the renewable energy industry, twice the number who work in fossil fuels.

The Northern German port city of Bremerhaven has staged a partial revival, after decades of decline following the collapse of the shipbuilding and fishing industries in the 70s and 80s. Just 10 years ago, unemployment peaked at 26% in this city. There has been a dramatic change in circumstance, as a result of new jobs in the wind energy industry, which is growing year on year. There are some dissenting voices to Energiewende. The Mittelstand (SME) enterprises that make up the core of the German economy are suggesting their competitiveness is blunted by high electricity costs. Their rationale is based on them having to pay the renewable levy on their energy bills, that certain larger industries are exempt from this charge. It is believed that far from damaging SMEs, the energy law can stimulate energy efficiency. The opinion at the federal level is that Energiewende is pushing sectors of German industry towards more ambitious innovation and is creating SMEs more capable of meeting future challenges.

5 EU Energy Innovations

In February 2015, the EU Commission adopted "A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy". The publication of this strategy created a new momentum to bring about the transition to a low-carbon, secure and competitive economy.

One objective of the Energy Union Strategy is to move further away from an economy driven by fossil fuels. In 2015, progress was made in three fields that lie at the heart of this transition: emissions trading, renewables, and further investments in low carbon technologies and energy efficiency.

There is a strong business case for this transition. Leading European companies are changing their business models. Renewable energy and energy efficiency are creating jobs in the EU, requiring new skills and investments. Many of the changes linked to this transition will take place in cities and municipalities; when our cities become smarter, they become key enablers of the EU's sustainable energy policies. It is evident that the EU electricity and gas markets are still not performing as they should, hence the need for further innovation.

The State of the Energy Union presents key building blocks for an implementation mechanism leading to more predictable, transparent and stable policies. The guidance on integrated national energy and climate plans provides the basis for Member States to start developing their integrated national energy and climate plans for the period from 2021 to 2030. The proposed methodology on key indicators is the first step towards measuring and monitoring the delivery of the Energy Union.

The EU is at the forefront of renewable energy innovation. EU private and public sectors invest approximately €4 billion per year in research and innovation for renewables. Moreover, 40% of all patents for renewable technologies are European, so there are huge opportunities in the renewable energy innovation market. In 2012, Europe's renewable energy industry employed around 1.2 million people and contributed to approximately €130 billion of economic activity, the vast majority of which did not exist just one decade ago. According to forecasts, similar prospects are to be expected from future developments in energy innovation. The challenge now is to invest in the big ticket items as well as macro technologies. An energy mix is needed to provide the optimal energy solution.

The next sections of this report explains technologies that are considered important to acknowledge as areas where energy innovation can support their development. Some technologies are not listed below, such as carbon capture and storage, since this report will concentrate on technologies that are targeted to the Northern Periphery and Arctic regions. These technologies are recognisable on the technology readiness level (TRL), hence investment opportunities are detectable.

5.1 Wave and Tidal Energy

Some tidal energy technologies have reached the stage where Original Equipment Manufacturers (OEMs) and utilities have secured finance for the first pilot array demonstration projects. Wave energy technology development is a little less advanced. For all developers in these sectors, however, the challenge of raising capital to invest in technology innovation and demonstration has slowed progress, with development being longer than originally anticipated, compared with technology innovations in other renewable energy sources. It is widely known that the industry faces other barriers, in the form of infrastructure. Across Europe, the wave and tidal energy resource is often strongest in areas where grid, port and harbour infrastructures are weakest, in an EU setting. However, this physical challenge is not unique to wave and tidal renewable energy, and the solutions developed in the expansion of more mature renewable energy technologies over the last two decades should be adapted for wave and tidal energy.

Despite all the challenges, wave and tidal energy provides excellent long term potential for economic growth, energy security and job creation. Policy makers at EU and Member State level are seeking innovative ways to accelerate commercialisation. According to Ocean Energy Europe; Industry Vision Paper 2013, agreeing a common plan and putting in place appropriate support will be essential steps towards industrialising these sectors and putting Europe on track to secure 100GW of installed capacity by 2050.

The potential for economic growth, energy security, job creation and global export inherent in wave and tidal energy technologies is considerable. Currently wave and tidal is considered at a pre-commercial state and lower on the technology readiness level. The emergence of wave and tidal technologies offer a renewable energy alternative in areas where the visual impact of electricity generation sources is a concern. Wave and tidal has the potential to leverage extra value by exploiting synergies with sectors such as offshore oil, gas, in a similar way that offshore wind did which resulted in efficiency gains and cost reduction to the end user.

The gains in creating a mature wave and tidal technology are considerable and are well known, however, the risks are equally significant.

- **Financial risk:** there is a shortfall in upfront capital investment for technology development and pilot array demonstration, which is compounded by the current lack of long-term clarity on revenue supports.
- **Technology risk:** uncertainties relating to survivability, reliability and cost reduction potential are inherent in all new energy generation technologies, but particularly in those designed for offshore operations in extremely harsh conditions in the areas that offer optimal conditions.
- **Project consenting risk:** unknown interactions between devices and marine environments and indeed communities make it challenging for regulators and developers to assess and mitigate potential impacts.
- **Grid-related risk:** the best and most economical resources are frequently not located near accessible grid infrastructure, creating grave uncertainty over connection dates in key areas, this can be especially difficult where there are cross border connections required.

Over the coming years, the EUs ability to reduce these risks will be the deciding factor when it comes to commercialising the wave and tidal energy sectors. For these sectors, it is clear that installing the first pilot tidal arrays will be a critical milestone in scaling up the industry. An EU coordinated approach between the EU and the wave and tidal industry is required to ensure that a shortfall of capital and revenue support does not stall the industry's progress by delaying the demonstrator arrays that are required to boost the roll out of the technologies.

5.2 Energy Storage

The amount of electricity produced and the amount demanded by consumers is often different. This causes an excess of energy at one moment and shortages at another. Energy storage can provide support in arranging these fluctuations in demand by allowing excess energy from times of lower demand to be saved for consumption in periods of higher demand. Energy storage will play a key role in enabling the EU to develop a low-carbon electricity system or empower the "EU super grid". Energy storage will supply more flexibility and balancing to the grid, providing a back-up to intermittent renewable energy supplies, essentially making provision for additional renewable energy sources.

Currently, there is limited storage in the EU energy system almost exclusively from pumped hydro-storage, mainly in mountainous areas such as the Norway, Sweden, Scottish Highlands etc. Other forms of storage such as batteries, hydrogen, chemical storage are either negligible, or at a very early stage of development. Some of the other forms of storage are showing they have a part to play in the energy transition but will ultimately require investment and demonstration. Energy storage is essential in an EU context for several reasons but primarily to balance supply and demand. Peaks and troughs in demand can often be anticipated and satisfied by increasing or decreasing generation at fairly short notice. The use of hydro schemes has proved valuable in this situation. In a low-carbon system, intermittent renewable energy makes it more difficult to vary output, and rises in demand do not necessarily correspond to rises in renewable energy source generation. It has been recognised that much higher levels of energy storage are required for grid flexibility and grid stability to cope and allow increasing use of intermittent wind and solar electricity etc.

European policies on reduction of CO_2 emissions require a shift towards intermittent renewable power while maintaining secure energy supplies. This presents a fundamental change to the current situation, as energy storage is a requirement to unlocking several components of the future low carbon electricity systems in the EU.

Decisions to invest into the development of storage and deployment of adequate storage capacity will depend on the evolution of the whole energy system, which is hampered by many variations in energy policy across the EU member states. Energy storage is inseparably linked to developments such as the electricity super-highways with large scale renewable energy sources in the North Sea through to distributed/regional renewable energy solutions. In addition, penetration of electric vehicles and improvements in demand response/demand side management/smart grids will provide for an energy secure future.

5.3 Energy Efficiency

As previously stated, EU policies can drive development with highly-advanced policy frameworks for Energy Efficiency. The Energy Efficiency Directive, the Ecodesign and Energy Labelling Directives, and the Energy Performance of Buildings Directive are the four pillars that boost innovation in the field. One of the 20-20-20 targets referred to earlier is the Energy Efficiency Directive, this policy provides the framework to achieve the 20% energy efficiency target in 2020, tapping energy savings potential in all phases of the energy chain, from generation to consumption.

European policies on reduction of CO2 emissions require a shift towards intermittent renewable power while maintaining secure energy supplies. This presents a fundamental change to the current situation, as energy storage is a requirement to unlocking several components of the future low carbon electricity systems in the EU. As for buildings, the Energy Performance of Buildings Directive Recast sets the target for all new buildings to be 'nearly zero-energy' by 2021. This enables the EU to decrease energy consumption, greenhouse gas emissions and energy bills considerably, especially if adopted in large scale renovation programmes of existing buildings.

The aforementioned Ecodesign and Energy Labelling Directives regulation measures on phasing out old, highly energy-consuming appliances and promoting new, energy efficient appliances has a direct stimulating effect on product development and innovation. For example, in 2009, almost 90% of refrigerators, washing machines and dishwasher's sales corresponded to an efficiency class equal or above 'A' class. On average, about 30% of new refrigerators sold in 2009 were in the highest efficiency class (labels 'A" or 'A++') compared to less than 10% in 2005.

Similar innovation can be seen across the EU for buildings. The introduction of energy efficient measures in buildings contributed to a significant decrease of the average energy consumption per dwelling for example, 11% for Ireland, 16% for Sweden, 27% for Denmark, with around 50% for Germany between 1990 and 2009. Besides regulation, innovation also needs effective financial instruments, from the public sector as well as the private sector if optimum targets are to be met. To accelerate the energy transition, the EU has stepped-up its efforts through the new EU 2014-2020 Financial Framework. 23 billion Euros are now ring-fenced for low-carbon investments under the European Structural and Investment Funds, this change will support energy innovation in product development, in addition to houses and buildings, which accounts for just under half of the total EU energy consumption per annum. Evidence shows that innovation in energy efficiency can bring about industrial growth, dynamic competition and job creation. It brings savings for consumers and promotes less dependence on energy. Innovation in energy efficiency is without doubt a huge opportunity for Europe as a whole, but certain "hotspots" of energy innovation is foreseeable, so Northern Periphery and Arctic regions must prepare and position accordingly. Many energy innovations in the building energy efficiency sector will be at a micro level, which is inextricably linked to the internet of things concept, as described in 5.4.

Energy expertise is not a prerequisite for energy innovation, a cross fertilization approach will be a common approach.

5.4 Digitalisation and the Internet of Things

The Internet of Things, is emerging as the next technology mega-trend, with repercussions across the entire energy industry spectrum. The IoT merges the physical and online worlds, opening up a host of new opportunities and challenges for companies, governments and consumers. Technology, particularly Internet of Things (IoT) applications, offers a range of possibilities for how electricity utilities can progress. IoT can improve the efficiency and performance of grid supply allowing a number of technologies to be fully integrated. But what are the main developments and advantage of IoT? Gathering data from sensors will improve the resilience of the grid and IoT will enable utility companies to use data to actively manage resources. This will improve the optimization of the resources, as stakeholders are able to make informed decisions about power usage and generation based on real time information.

The unprecedented convergence of forces reshaping utilities industries, from moderating demand and aging infrastructure to environmental policies and the creation of distributed energy resources requires increasingly flexible and robust grid systems. The electricity grid is evolving from a one-way system where energy flows from centralised generation stations to consumers, to a platform that can detect, accept, and control decentralised consumption and production assets so that energy and information can flow as needed in multiple directions. The industry vision is known as the "smart grid." This intelligent grid builds on the industry's innovative heritage of increasing linkage using sensors, smart devices, and networked operations. Achieving it will require countless innovations of technologies, that are evolving with time including many IoT applications. At the heart of these advances are technologies like sensors, robotics, and advanced analytics, which together form advanced, interconnected systems capable of quickly analysing large amounts of data. These critical systems are the brains capable of giving electrical generation/distribution systems the flexibility and agility necessary to enable ideas like a self-diagnosing grid which essentially forms a plug-and-play generation.

John Hagel III, et al suggests that these innovations are indeed exponential, accelerating innovation in the electrical energy industry. He states that the cost-performance curve of three core digital technology building blocks—computing power, data storage, and bandwidth utilisation has been improving at an exponential rate for many years. As the rate of improvement accelerates rapid advances in the innovations built on top of these core "exponential" technologies is expected.

It is important to note that there is not exclusive focus entirely on technology—rather, technology needs to be considered and planned for within the context of a utilities capability model. The utilities barriers to the adoption of these new IoT tools is high in respect to R&D, but the risk and cost of not pursuing them is greater. Innovations throughout every aspect of the renewable energy sector is now possible, because of our ability to apply more connectivity and computer intelligence to every single aspect of renewables, whether it's generation, transmission, or deep analytics into the efficiency of operations.

5.4.1 Example of IoT in Practice

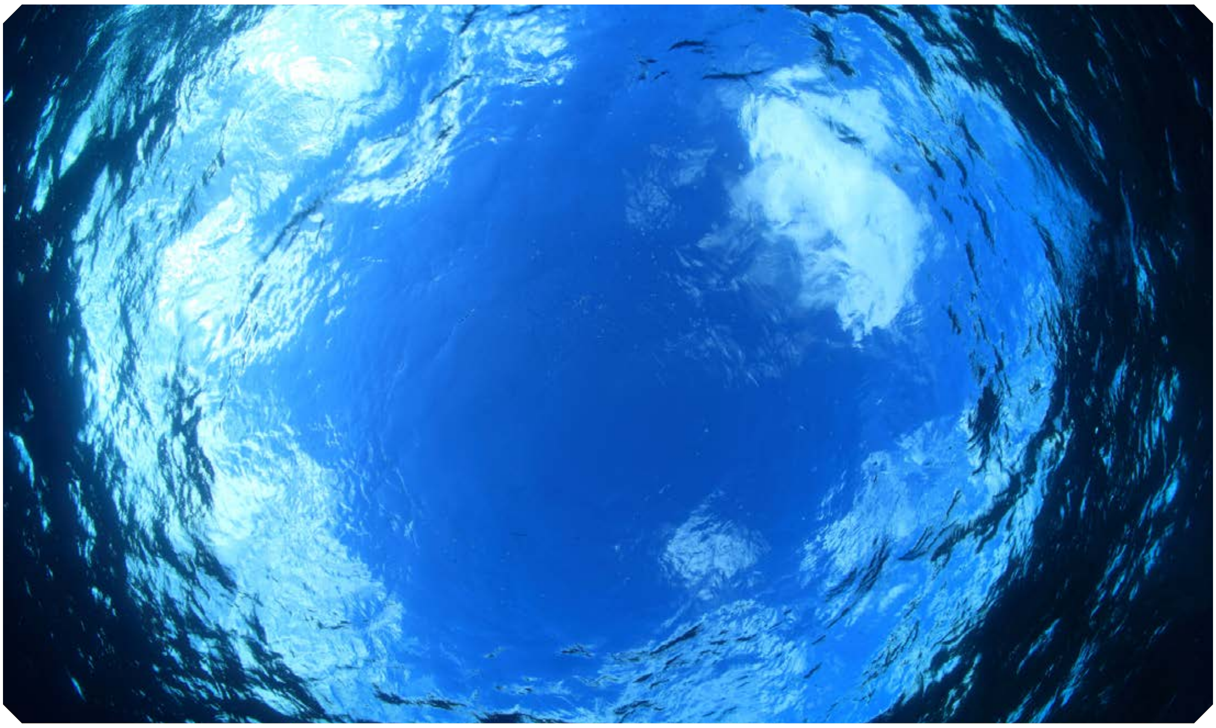
In homes across the EU, the Internet of Things will enable energy consumers to build their own temperature controlled systems with their properties, and better manage their energy usage. IoT makes it entirely feasible today for someone with just a little bit of technical knowledge to build their own local micro-weather forecasting system. Now given this, one could link it to their intelligent home energy control system, one of the fastest-growing home-based IoT categories. Further, build in some renewable energy source technologies like solar, wind energy capability and link your own personal big data to that technology, in order to come up with the most optimal time to generate your own individual power house. Scale this up to what's possible in the industrial sector and the opportunities are enormous. Global companies with large-scale facilities now have the ability to monitor and manage all their energy infrastructure across a huge geographical area from one central data viewpoint.

5.4.2 Example of a future scenario

In the very near future, significant amounts of excess renewable energy (in the order of TWh) will start to emerge in countries across the EU, with surpluses characterised by periods of high power output (GW) far in excess of what is demanded. These periods will alternate with times when solar PV, wind and other renewable energy sources are only generating at a fraction of their capacity, and non-renewable generation capacity will be required. In addition, the large intermittent power flows will put strain on the transmission and distribution network and make it more challenging to ensure that the electricity supply matches demand at all times. Therefore, innovation is required in order to provide for a balanced system and predicable future.

With respect to the aforementioned, new systems and tools are required to ensure that renewable energy is fully integrated into the power system effectively, with storage offering the base load requirements.

According to the Fuel Cell Hydrogen Joint Undertaking there are four main options for providing the required flexibility to the power system: dispatchable generation, transmission and distribution expansion, demand side management, and energy storage. All of these options have limitations and costs, and none of them can solve the renewable energy source integration challenge alone. Some of the limitations are as follows: in meeting EU 2030 targets with high proportions of renewable energy sources installed, there will still be periods with large amounts of excess renewable energy that cannot be used in the electric power system directly or through power to power storage. Studies have shown that demand for storage differs significantly between countries with different generation profiles. In particular, large reservoir hydro capacity such as in Sweden is a carbon-free option to integrate renewables and eliminate the need for further storage. By contrast, non-



interconnected islands, or markets that behave as such, are a suitable early market for storage driven by emerging renewables curtailment and very high fossil generation costs. Depending on the island characteristics, there may already be economic demand for storage reaching tens of percent of installed power generation capacity.

Given this, it is suggested that further development of characteristics is undertaken across the Northern Periphery & Arctic regions to determine their generation profile. One consideration is alternatives that can be derived from excess renewable energy, such as conversion of electricity to heat as heat storage is a proven and relatively low-cost option for providing flexibility to the power system. As increasing variable renewable energy penetration will drive higher volatility in electricity prices, the business case for and penetration of heat storage will improve further. Conversion to heat and heat storage will be able to utilise a part of the excess renewable energy and reduce the required non-renewable energy source generation. However, the potential of conversion to heat to integrate variable renewable energy is limited by the share of electricity demand used for heating and its seasonality.

Conversion of electricity to hydrogen through water electrolysis and use of this hydrogen in the gas grid, power to gas, mobility or industry can productively utilise nearly all excess renewable energy in a high proportion of installed renewable energy source circumstances, contributing to the decarbonisation of these sectors. European potential for installed electrolyser capacity in conditions outlined above would be in the hundreds of GWs. This requires that there either is local demand for hydrogen at the production site or that the hydrogen can be economically transported to a demand centre. This requires regional deliberation as the many different applications are possible across a range of sectors from the aforementioned illustration.

6 Conclusions

The EU is developing tools to integrate renewables into the electricity market. The most significant need is energy storage.

The EU aims to have consumers at the centre of EU energy policy, to benefit from new technologies, to reduce their bills and to participate actively in the market. At the same time, the cost of renewables is falling. For instance, photovoltaic module prices dropped by 80% in five years. In 2014, the EU had 10 times more residential solar panels per citizen than the rest of the world, which demonstrates that innovation can and does provide change. Renewable energy is becoming cost competitive, with the EU leading the global renewables industry, but it cannot be complacent as opportunities are globally competitive.

Nevertheless, renewables power our economy and fuel our recovery. Over the past five years, the renewable energy sector has provided almost half a million new jobs and now generates around 140 billion euro in turnover – which is a perfect illustration of the fact that it is possible to combine growth and jobs creation with the fight against climate change. The European renewable energy sector employs 1.15 million people, representing over 2 renewable energy related jobs per 1000 inhabitants, which is twice the world figures. That makes the EU a major player on the international market and home to successful clean energy companies, such as the world leader in wind turbine manufacturing.

However, the problem the EU faces is not a lack of technical solutions but a lack of time in the implementation and finance to meet targets. The longer it takes to adjust the EU energy system, the more difficult and costly it will be, with an unknown impact on the environment, energy price and security. The need for greater innovation in energy was one of the strongest points of agreement at the recent Paris talks. Some have suggested that the most important news to come out of the conference was not the final accord, signed with great fanfare by the governments of 195 countries, but the commitments made by governments and wealthy individuals to research and develop technologies that can help the climate. Renewable energy is still subsidised in much of the EU at various levels, if the policy regime changes, the pay-offs for innovation can change, this equates to risk. Subsidies that are not time bound create an additional element of political risk in any investment appraisal so longer term polices are required at an EU level cascading into regional regulation that are attractive to the private sector. The State of the Energy Union presents key building blocks for an implementation mechanism leading to more predictable, transparent and stable policies with respect to renewable energy. The question now is; can theory be put into practice across the EU?

The EU lags behind in the deployment of some key technologies. The European Commission set development policies only for renewable energy source deployment and not for key technological transformation such as digitalization and energy storage. Similarly, the European Commission set targets only for renewable energy source deployment, underestimating the role of non-renewable energy resource technologies in energy transition. This could prevent EU member states from developing pivotal technologies in the future and does not provide adequate incentives to direct financial resources to technologies currently not yet mature for commercialization but with high potential. Regarding the most innovative energy technologies applicable to the EU, The Strategic Energy Technology Plan (SET-Plan) has identified 21 main energy technologies as key to Europe's effort to decarbonize its economy and increase energy efficiency. Only some of the identified technologies are applicable to the Northern Periphery and Arctic programme area. New technologies are being deployed as the energy systems become "smarter" New technologies – such as smart grid technologies, energy storage, demand-side management, energy efficiency solutions and electric vehicles – can make energy systems more efficient and resilient, but are also a key step in integrating larger amounts of renewable and distributed energy generation into the system.

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