COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL

Accelerating Clean Energy Innovation
1. **Introduction**

Accelerating the transition to a low-carbon competitive economy is both an urgent necessity and a tremendous opportunity for Europe.

It is the defining challenge of our time. Failure will put our welfare at stake. Success will open unprecedented economic opportunities and a new higher plane of prosperity, welfare and growth.¹

The European Union is well placed to lead this transition, which received new momentum and direction from the Paris Agreement.² Europe has spearheaded global efforts to fight climate change, has been a driving force in developing renewables, and leads the world in energy-efficiency solutions for industry, transport, buildings. Europe’s businesses have built a comparative advantage in many world markets and European scientists and innovators are pushing the frontiers of knowledge.

Based on these strong foundations, the Commission is laying out a clear framework for action, based on three overarching goals:

- Energy efficiency first
- Europe as the global leader in renewables
- A fair deal to consumers

Accelerating clean energy innovation is essential to achieve each of these goals. Europe needs to step up its investment in energy efficiency and renewable technologies, and the development of clean energy business models, embracing the new opportunities and consumer empowerment brought about by digitisation.

The core investment has to come from the private sector. But the European Union can and should play a decisive role. This Communication lays out a comprehensive strategy for the three main policy levers the EU can deploy to boost private investment in clean energy innovation.

- The EU can set the political ambition and create the right business environment through targeted signals, policies, standards and regulations. This is about setting strong and consistent incentives for private investment in clean energy research, development and deployment. EU-level policy and regulatory frameworks need to prioritise energy efficiency, set a high ambition for global leadership in renewables, and place the consumer at the centre of the energy system.
- The EU can also deploy targeted financial instruments to lower the risk of private investments in untested but promising clean energy technologies or business models. This is about using public loans, equity investments and financial guarantees in projects that are unlikely to find full funding from the private sector.

¹ Global market projections for low-carbon and energy-efficient solutions range from about EUR 1,600 billion to EUR 4,400 billion per year, with high growth potential especially outside Europe.
due to market, technological or scientific uncertainty. With these EU instruments, as demonstrated by the Investment Plan for Europe, the risk for the private sector is reduced, enabling private investment that otherwise would fail to happen;

- The EU can focus its research and innovation funding, in particular through Horizon 2020, to push the frontiers of science and knowledge. This is about funding curiosity-driven research, mission-oriented research and demonstration projects in order to encourage and accelerate the transition from the lab to successful goods and services that create jobs and generate growth.

In addition to these three categories of action, the Union has an important role in engaging in international initiatives on clean energy innovation, and enabling coordinated efforts with cities, regions and Member States.

This strategy explicitly serves two core political priorities of the European Union: building a resilient Energy Union with a forward-looking climate change policy – of which it is a core deliverable – and giving a new boost to jobs, growth and investment. At its heart lies a co-ordinated effort to promote and develop enabling technologies, services, business models, and social innovation, thus contributing to growth and employment and making EU industries more competitive in world markets.

2. A CHANGING ENERGY SYSTEM

The energy system has reached a tipping point. Renewables are increasingly cost-competitive and account for growing shares of electricity generation. Energy intensity rates – measuring energy use in relation to economic output – are falling, particularly in developed economies. The EU can take much credit for these successes, although much more remains to be done. Its leading role in battling climate change has made European industries the most energy-efficient in the world, and turned them into global innovation leaders churning out new technologies, materials, and solutions. From the start, the EU’s climate and energy policy has followed a holistic design, best expressed in the just-updated Strategic Energy Technology (SET) Plan, aimed to coordinate investments by the EU, Member States, and industry, as well as to align relevant policy and regulatory frameworks.

But reaching higher levels will require stepping up this work. There is a need for new solutions for energy storage, and developing a broader portfolio of cost-effective renewable technologies. Similarly, there needs to be a much faster adoption of existing energy-efficiency technologies across building stocks, transportation systems, and manufacturing practices.

More fundamentally, the transition to a low-carbon and climate-resilient economy will require a more decentralised, open system with the involvement of all society. The energy system has traditionally been marked by the dominance of large companies, incumbents and large-scale, centralised technological projects. But in future the consumer has to be at the centre of the energy system: demanding competitive low-carbon solutions; participating as producer and manager of decentralised energy networks; acting as an investor, through decentralised platforms; and driving change through user innovation.
A more bottom-up, user-centred energy system is a driver for more innovation. And at the same time, this decentralisation is made possible through other innovations, chief among them the digitisation of core aspects of the energy market and transport system. Today, and even more tomorrow, digitisation means lower barriers to entry. This means that the consumer, the local community and the small start-up can participate and even lead in the development of energy innovations.

Fostering low-carbon innovations, energy efficiency projects and renewables requires a system of open innovation. Companies and industries increasingly understand that the complexity of today’s world means that no single entity can come up with a complete solution. Furthermore, the most interesting market-creating innovations are happening at the intersection of sectors, disciplines and approaches.

3. **POLICY SIGNALS AND REGULATORY FRAMEWORKS**

Clean-energy innovation requires a well-functioning single market and a robust competition policy, which gives smaller newcomers an opportunity to bring their innovations to the market. Completing the Capital Markets Union will mean more opportunities for cross-border flows of capital and a greater emphasis on sustainable finance using instruments such as green bonds. This means more funding opportunities to innovative projects in the area of energy efficiency and renewables. An open innovation and open science approach will mean more opportunities to bring research results to the marketplace.

In addition to these broad pre-requisites for a better innovation ecosystem, the acceleration of clean-energy innovation will require important changes in energy subsidies and energy-specific regulations.

**Subsidies**

The remaining but still significant policies benefitting oil, coal and other carbon-intensive fuels, including subsidies by some Member States, should be seen as an obstacle to clean-energy innovation. These policies mask the true societal cost of fossil fuels and artificially lower their prices. This makes life harder for innovative clean-energy projects which then have to face harsher market conditions.

These policies are also fiscally expensive and are in direct contradiction to EU commitments under COP21, the G20 and the G7. The Commission's report *Energy prices and costs in Europe*,³ issued together with this Communication, finds that annual fossil fuel subsidies stand at around €31 billion⁴. This figure does not include environmental externalities, tax expenditures and other forms of incentive to fossil fuels, and adding these

³ See, [SWD (2016) ...].

⁴ See, [SWD (2016) ...]. For example, in 2012 subsidies to coal and gas amounted to €16 billion, including €5 billion in investment grants, €3 billion in fuel tax exemptions, €3 billion in feed-in tariffs and €1.5 billion in support to electricity production.
amounts\textsuperscript{5} would increase the total amount of fossil fuel subsidies in the EU in 2012 to a staggering €171 billion. In a context of scarce resources, the fiscal burden of these instruments means fewer resources that could potentially be devoted to public funding for clean-energy research and innovation. The situation becomes clear when comparing the €31 billion of direct fossil fuel subsidies with the total of €5.3 billion in European public energy and climate-related research and innovation (€4.2 billion in 2014\textsuperscript{6}, by the 28 EU member states plus €1.1 billion from the EU’s Horizon 2020 program).

Promoting renewable energy technologies is a central plank of the EU’s global leadership of the clean technology transition. The Electricity Market Design directive, in conjunction with strengthened carbon prices, aims at reducing the need for specific support schemes. This would allow to progressively focus public support on less mature renewable electricity technologies and complement research and innovation efforts by market pull instruments for those technologies.

The time is ripe for changes. Current low oil and gas prices provide a window of opportunity for phasing out fossil fuel subsidies without adverse effects on social welfare. Accordingly, the leaders of the G7 countries and the European Union, at their meeting of 26–27 May 2016, encouraged all countries to do so by 2025.\textsuperscript{7} The European Commission is leading the way with its own policies and instruments. According to OECD and IEA figures, a significant share of calculated subsidies result from preferential tax treatments of fossil fuels, something the Commission is examining in the context of the wider reflection on energy taxation in the EU.

The enabling framework adopted today \textit{[exact reference]} sets out a range of actions to help redirect financial flows towards the clean energy transition, including measures to reinforce transparency on the issue of subsidies and their effect on innovation.

\textit{Regulation}

Creating the right market conditions for innovation includes putting in place a stable, long-term, transparent and predictable regulatory environment. Standards matter greatly, too. The Commission recently presented the revised Better Regulation package, recognising that innovation needs to be thoroughly considered in any new legislative proposals. This is fully in line with the “innovation principle”.

Regulation can accelerate the emergence of innovative low-carbon technologies and act as a spur for greater competitiveness, facilitating the emergence of better-functioning, sufficiently large markets and greater policy certainty. The Commission is putting forward, together with this Communication, a broad package of legislative and non-legislative measures under the Energy Union. These measures will provide a clear framework for the uptake of the innovations that are needed to achieve the objective of the competitive low-carbon economy. For example, the redesign of the European electricity market will support the penetration of renewable-energy sources and unlock regionally integrated energy

\textsuperscript{5} €86.2 billion for coal and €53.8 billion for gas

\textsuperscript{6} €4.2 billion in 2014

\textsuperscript{7} The European Commission is leading the way with its own policies and instruments.
markets; the Energy Performance of Buildings directive will create incentives for the development of innovations to achieve a European building stock of nearly-zero-energy houses and deliver energy-plus districts by 2050; and the revised Renewable Energy Directive (RED II) will spur the development of the next generation of renewable-energy solutions.

Existing Commission proposals to review the EU Emission Trading System (ETS), the Effort-Sharing Regulation, as well as CO₂ emission and absorption from the land use sectors will likewise stimulate low-carbon innovation. The action plan for the Circular Economy and the coming update of the bio-economy strategy will contribute to increasing energy efficiency and reducing emissions by better using raw materials and recycling secondary raw materials and waste. The decarbonisation of transport will act as an additional "pull" factor for innovation. The recent Communication on a European Strategy for Low-Emission Mobility⁸ contains an action plan to facilitate the transition to low-emission mobility and provide new opportunities for innovation, job creation and for reducing Europe’s energy dependency. Public procurement will serve as a further powerful instrument to create markets for innovative products.

Policy signals and regulatory frameworks – Proposed actions:

- The Commission will implement the Innovation Principle in forthcoming policy and legislative initiatives under the Energy Union, including via the application of the revised Innovation Tool of the Impact Assessment guidelines.
- Future annual Union work programmes for European standardisation will target Energy Union priorities, notably the decarbonisation of the economy and support for green public procurement.
- The Commission will support the energy transition through regulatory frameworks for public procurement, including the revision of the Clean Vehicles Directive (Directive 2009/33/EC), and further development of Green Public Procurement criteria, including for urban mobility and smart cities and communities.
- The Commission will also examine, when reviewing the guidelines on State aid for environmental protection and energy 2014-2020 how those rules, together with the State aid rules for R&I investments, enable Member States to stimulate innovation in renewable energy technologies and solutions.

4. **FINANCIAL INSTRUMENTS TO BOOST PRIVATE INVESTMENT**

To ensure a competitive low-carbon economy, Europe needs to mobilise substantial amounts of private-sector investment. The International Energy Agency estimates that globally €4.6 trillion in clean energy investment – for R&D as well as deployment of mature technologies – is required by 2020 to follow a track conducive to limiting global warming to 2°C.⁹ Against this figure, current private-sector investments in Energy Union

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⁸ COM(2016) 501 final
research and innovation priorities, estimated at €22.9 billion in 2014, are clearly insufficient.

These new investments have to target the critical stage of scaling up low-carbon, energy-efficient solutions, taking them from the demonstration stage to the market. This stage typically requires high levels of investment but the remaining uncertainties regarding cost, performance and market integration create too high a risk for private-sector investors.

First-of-a-kind, commercial-scale demonstration projects present a particularly high risk for private sectors. To address these types of projects, the European Commission, together with the European Investment Bank (EIB) last year launched the Energy Demonstration Projects (EDP) facility as part of Horizon 2020 InnovFin. EDP has proved its relevance by generating strong interest to provide loans or loan guarantees to first-of-a-kind low-carbon technologies in renewables and fuel cells and hydrogen.

Other large investments in renewables and energy efficiency also present technological or market risks that are higher than can be financed by normal bank loans. The European Fund for Strategic Investments (EFSI) is the key instrument in this regard: already more than 25% of its current investments in more than 40 projects are leveraging finance in the Energy and Environment and resource efficiency priority sectors, representing an estimated amount of triggered investments of up to EUR 30 billion. The Commission's EFSI 2.0 proposal underlines the success of this instrument, doubling the Fund both in terms of duration and financial capacity, and earmarking half of the financing for low-carbon investments. 11

To achieve scale and maximise impact from EFSI and other financial instruments, there needs to be a strong pipeline of innovative projects that reach investment and market readiness. The research Public-Private Partnerships (PPPs) such as the Joint Technology Initiatives (JTIs) on Fuel Cells and Hydrogen, CleanSky, Single European Sky Air Traffic Management Research (SESAR), Shift2Rail, and the BioBased Initiative, as well as contractual PPPs, e.g. Green Vehicles and SPIRE, represent an important source of new investment, resulting from R&D co-financed with industry, and provide a project pipeline. Another key source of new clean energy investments and subsequent project proposals that are ready for EU financing will come from the Knowledge and Innovation Communities (KIC), in particular the KIC-InnoEnergy and Climate-KIC. The KICs are instrumental in connecting European sources of R&I funding, such as Horizon 2020 and the European Structural and Investment Funds, with private partners and bridge regional and local activities to enterprises, start-ups and SMEs. Their work will be extended to advisory services on access to capital, technical assistance or business models proposals.

The Commission seeks to leverage EU public funds through mobilising private investments. The Commission proposal on the revision of the EU Emission Trading

11 COM(2016) 581 final
System (EU ETS) is putting forward an Innovation Fund as a successor to current NER 300 facility. Swift implementation of the Innovation Fund should support investments into highly innovative low-carbon technologies for energy-intensive industries, as well as for renewable energy and Carbon Capture, Storage and Use. All these efforts require strong linkages with other EU instruments, particularly InnovFin EDP, EFSI and the European Structural Investment Funds (ESIF).

Financial Instruments to boost private investment – Proposed actions

- The budget of the InnovFin Energy Demonstration Project (EDP) scheme will be at least doubled, using funds channelled from different sources including Horizon 2020, the European Fund for Strategic Investment and other instruments. Its scope will be expanded as well. Synergies with other instruments will be ensured, aiming for a one-stop advisory facility to orient potential investors and developers among the different instruments available.

- The future ETS Innovation Fund should support investments in low-carbon innovation in renewable energy; carbon capture, storage and use (CCS/CCU); and in energy-intensive industry. The Commission also has proposed enabling the start of the Innovation Fund before 2021.

- The Commission and the EIB will set up a Clean Transport Facility to support alternative energy transport solutions. A pipeline of relevant projects will be supported through targeted collaboration initiatives, such as through a new deployment initiative for clean (alternatively fuelled) buses.

- The Commission will bring innovative projects to the attention of investors of the relevant PPPs supported under Horizon 2020 and the Knowledge and Innovation Communities (KIC) InnoEnergy and Climate of the European Institute of Innovation & Technology (EIT).

5. FUNDING ENERGY SCIENCE AND TECHNOLOGY AND ITS MARKET ADOPTION

The European Union is one of the global leaders and largest public funders of clean energy research and innovation. Horizon 2020 includes an allocation of 5.7 billion euro for the societal challenge 'secure, clean and efficient energy'. Combined with other areas of Horizon 2020, over €10 billion in energy funding is dedicated to clean energy research and innovation. This is complemented by significant investments from the structural funds, in particular through the smart specialisation strategies.12

Building on this success, expanding the frontiers of science and knowledge is a necessary condition for ensuring the quality and impact of future European investments towards the low-carbon economy. This is addressed through various elements of Horizon 2020:

12 http://s3platform.jrc.ec.europa.eu/
Curiosity-driven research: Horizon 2020 funds ground-breaking curiosity-driven fundamental research through the European Research Council (ERC). Since 2007 the ERC has awarded 248 grants to research projects in the area of energy, amounting to roughly €500 million of EU funding.

Market-creating innovation: As a new initiative, the Commission intends to strengthen support for innovation – with a particular focus on start-ups and SMEs – through a European Innovation Council. The aim is to improve the likelihood of capturing, supporting and scaling up the most interesting examples of market-creating disruptive innovations in Europe, in a bottom-up and interdisciplinary manner – for example at the intersection of energy, transport and digital technologies. A first set of measures will be introduced in 2017 under Horizon 2020 and the Commission will look to strengthen this approach in future programmes.

Mission-driven research and innovation: the Commission will test out new approaches inspired by best practice internationally. This includes approaches that combine a directive, mission-driven way of identifying and selecting projects with high potential impact; direct involvement in the day-to-day management of the project and various forms of targeted, tailor-made assistance; as well as discretion powers to restructure or terminate funding if agreed milestones are not reached (exemplified by the U.S. ARPA-E/Advanced Research Projects Agency-Energy).

Inducement prizes: The Commission will use inducement prizes as a bottom-up instrument to deliver break-through innovations, giving contestants complete freedom to devise the most effective solutions. This builds on experience so far in Horizon 2020 (€8.25 million for five on-going clean energy prizes).

In addition to the focus on clean energy research and innovation, delivering this Communication will require to involve other areas:

Climate research: Horizon 2020 is supporting research that will feed into the upcoming 2018 Report by the International Panel on Climate Change (IPCC). This report will present the research findings on the 1.5°C global warming scenario and will undoubtedly bring a sharper focus to the EU’s own efforts going forward. In this context, a European Decarbonisation Pathways Initiative, steered by a High-Level Panel, will develop science under Horizon 2020 to help identify feasible and credible pathways compatible with the Paris Agreement.

Transport research: Horizon 2020 supports the decarbonisation of the transport system, by advancing the energy efficiency of vehicles, electromobility and battery technologies, shifting towards environmentally friendly mobility solutions, and driving digitisation for more efficient transport and mobility. The activities will promote the emergence of new business models and innovation-friendly standards and regulations, in particular in urban areas. R&I action will complement ongoing policy action to support roll-out of mature innovative technologies, such as in zero-emission public transport or intelligent transport systems.
Social sciences and humanities: To deepen understanding of behavioural or other socio-economic conditions related to social acceptance of – or opposition to – climate and energy-related policies, the Commission is putting in place a new interdisciplinary energy-research platform. It will draw on contributions from energy specialists in the social sciences and humanities as well as more technical fields, in view of making proposals to European policymakers.

Examples of European clean energy innovation projects supported by Horizon 2020:

- The InnovFin Energy Demo Project Facility has provided a €10 million loan for a first-of-a-kind full-scale demonstration project for the WaveRoller concept of Finnish company AW-Energy. The project aims to bridge the gap between demonstration and commercial deployment of wave-energy conversion into electrical power, which shows high global market potential.

- The EIB has provided a quasi-equity loan of €20 million under the InnovFin Midcap Growth Finance program to Heliatek from Germany. The company invented and patented a unique technology to produce electricity-generating solar films (Heliafilm®), using organic photovoltaics (OPV) which can be integrated in glass or façade elements, or can be applied to rooftops.

- The ELIPTIC (Electrification of public transport in cities) project has received € 6 million from Horizon 2020 for exploring ways to electrify urban public transport systems, by optimising the use of existing infrastructure in European cities - making public transport the backbone of electric mobility, thus leading to reduced fossil fuel consumption and improved air quality.

In order for Europe to become a leader in renewables, key bottlenecks that need to be addressed are the integration of renewables into the energy system, as well as developing advanced storage solutions to ensure a stable energy supply for households and industry. Furthermore, to make a major step towards achieving the energy-efficiency-first principle, the decarbonisation of the EU’s building stock must be tackled, as it is responsible for over 40% of the EU’s final energy demand. In addition, the transport system poses enormous potential to cut CO2 emissions, but to do so it requires storage solutions and digital innovation to support transport and smart mobility services.

To create a sustained impact and capitalise on the opportunities in terms of lowering CO2 emissions, industrial competitiveness and export opportunities from the above-mentioned issues, building on the SET Plan, the Commission will focus its clean energy funding under Horizon 2020 on the following four areas:

1) Energy storage solutions: To facilitate and enable the transition to a low-carbon energy system (including transport) based largely on renewables, the EU needs to accelerate the full integration of storage devices (chemical, electrochemical, electrical,
mechanical and thermal) into the energy system, at domestic, commercial and utility scale.\(^\text{13}\)

2) Electro-mobility and a more integrated urban transport system: Rapid development and deployment of next-generation electric vehicles based on advanced battery designs and new powertrains, an innovative recharging infrastructure and associated business models and services are key elements of the future low-carbon mobility, along with a more integrated urban transport system using new digital technologies to improve energy efficiency.

3) Decarbonising the EU building stock by 2050: From nearly-zero energy buildings to energy-plus districts: The EU’s building stock represents a total floor area of around 25 billion m\(^2\).\(^\text{14}\) Buildings consume 40\% of the EU’s final energy demand, more than any other sector. But buildings also represent a large energy-savings potential and once renovated and upgraded, they can help to generate surplus power or provide key energy storage capacity.

4) Integration of renewables (RES): Further system integration and developing the next generation of renewable-energy technologies, including potential game-changers, is required for renewables to become the dominant source of primary energy production and power generation.\(^\text{15}\) It is also a prerequisite for the transformation of carbon-intensive sectors, such as transport,\(^\text{16}\) where strong incentives to innovate in alternative energy forms (like advanced biofuels) are needed. This includes dedicated research and innovation support, in close collaboration with industry, for Europe to maintain its global leadership in renewable-energy technologies.

\(^\text{13}\) Current EU support for storage-related R\&I is provided mainly as part of the smart-grids activities of the SET Plan and in the context of the Fuel Cells and Hydrogen Joint Undertaking.

\(^\text{14}\) See, Europe’s buildings under the microscope (2011).


Funding energy science and technology and its market adoption – Proposed actions

To reach the goal of making the EU the world leader in clean energy solutions, funding from the EU budget needs to focus on disruptive innovation, incremental innovation and a number of targeted high-impact projects. To implement this ambition:

- Horizon 2020 is developing a reform agenda under the banner of a potential European Innovation Council, to better support potentially disruptive technologies, innovations, and business models. While this approach will be bottom-up, it is expected that it would support breakthrough innovations for the low-carbon economy which are not foreseen in strategic, mission-driven funding.

- The Commission will invest more than EUR 2 billion from the Horizon 2020 work programme for 2018-2020 (representing a 35% budget increase in annual terms from 2014-2015 levels) to support research and innovation projects in four priority areas: (1) Energy storage solutions; (2) Electro-mobility and a more integrated urban transport system; (3) Decarbonising the EU building stock by 2050: from nearly-zero energy buildings to energy-plus districts; and (4) Integration of renewables, including advanced biofuels.

- The Commission will reinforce the support provided with structural funds through the Smart Specialisation Platforms, notably the ones on energy and industrial modernisation, as a springboard for regional innovation and industrial clusters. The four priority areas will be further targeted, mobilising public and private stakeholders in synergy with other EU instruments and funding schemes.

- In the context of the existing Horizon 2020 funding instruments and rules, the Commission will set up a pilot scheme combining a directive, mission-driven approach to identifying and selecting projects with high potential impact; direct involvement in the day-to-day management of the project and various forms of targeted, tailor-made assistance; as well as discretionary powers to restructure or terminate funding if agreed milestones are not reached (exemplified by the U.S. ARPA-E/Advanced Research Projects Agency-Energy). The scheme will emphasize quick impacts and market relevance reached.

- The Commission will launch a flagship Energy Innovation inducement Prize for EUR 5 to EUR 10 million to reward a breakthrough innovation in one of the following areas: (1) Artificial photosynthesis; (2) Low cost, nearly-zero energy building (NZEB) design and construction; (3) Community-based energy trading scheme; or (4) Social innovation in energy and/or transport at city level.

6. LEVERAGING EUROPE’S GLOBAL ROLE

In line with the Commission’s priority to be a stronger global actor, Europe needs to draw greater value from its role as global climate champion and pioneer of low-carbon and energy-efficient solutions, to ensure that it remains at the centre of global value chains, with associated benefits for its manufacturing industry and worldwide exports. Climate finance and the implementation of national commitments are stimuli for global technology
cooperation and to create market opportunities for European businesses. The Paris Agreement underlines the role of research and innovation, in particular in cooperation with developing and emerging economies, based on systemic observation.

Growing global energy needs, in particular in emerging markets, present significant export opportunities for European companies to supply low-emission technologies, including, where applicable, 'frugal' innovations that are adapted to local conditions. New strategic partnerships, especially with emerging economies, are needed to drive innovation and create markets.

Close cooperation with international partners is of high strategic value. The importance of international cooperation is underlined by the decision of the European Commission in 2016 to join, on behalf of the EU, the Mission Innovation initiative. Mission Innovation was launched at COP 21. Currently 21 countries (of which seven are EU Member States) and the EU are members, committed to doubling their public clean energy research funding over five years. Mission Innovation will help reverse the decline in public expenditure for clean energy research, which is still below its previous peak\(^\text{17}\) and nowhere near the much higher levels needed to attain the goals of the Paris Agreement. Furthermore, it will align the focus of public expenditure with large private investors, for example through interaction with the Breakthrough Energy Coalition. The EU will play a leading role in Mission Innovation and will have a specific focus realising synergies with the Breakthrough Energy Coalition. Mission Innovation members have identified seven Innovation Challenges which are critical to achieving a low-carbon society. The EU will lead the Solar Fuels and Solar Chemicals Innovation Challenge and will participate actively in the other Innovation Challenges, in close cooperation with other Mission Innovation members.

Through science diplomacy, strengthening strategic research partnerships and exchanging knowledge, expertise, technology and qualified personnel with key countries, the European Commission will support developing and emerging countries in their energy transition. In particular, the recently adopted European External Investment Plan (EIP) with its European Fund for Sustainable Development (EFSD), which has the objective of spending 20% (some €9 billion) of its funding on renewable energy and climate action, will attract private investment to African countries, which can be of crucial importance in rolling out low-carbon energy infrastructures and supporting innovative energy solutions. These objectives will be closely linked to Europe's international climate, trade and development cooperation. Similarly, the EU will use its trade policy instruments and related technical assistance to encourage third countries to adopt climate-neutral solutions.

The Open to the World policy of Horizon 2020 targets researchers and innovators from developing countries to work side-by-side with Europeans in developing those low-carbon energy technologies and solutions that are best suited to local circumstances. This will boost market opportunities for EU companies and help EU exports, as well as strengthen

\(^\text{17}\) Public energy RD&D spending in IEA member countries, OECD/IEA (2015).
the capacities of developing countries and harvest the benefits of international scientific collaboration in bringing new technologies to market.

**Leveraging Europe’s global role – Proposed actions:**

- The Commission will use the EIP and the EFSD to leverage more investment in the field of low-carbon energy in Africa and the EU's neighbourhood, as well as to provide more advisory services, building on its Technical Assistance Facility.

- The Commission will work with Member States such that the European Union plays a transformative role within the global Mission Innovation initiative. It will lead the Converting Sunlight Innovation Challenge and the Affordable Heating and Cooling of Buildings Innovation Challenge, and take an active part in the other five innovation challenges. The Commission will focus on realizing synergies with the private sector including the Breakthrough Energy Coalition.

- The Commission will work with Member States to launch one or two joint deployment programmes in developing countries in the areas of energy efficiency and renewables, with a focus on Africa as a privileged partner in view of the EU-Africa summit in 2017. Such programmes will couple research and innovation with capacity building in the host country as both components are indispensable elements for reaching success on the ground. The EU financial contribution will consist of matching contribution originating from Horizon 2020 and Development cooperation programmes. The initiative will be complemented by technical assistance where needed.

- The Enterprise Europe Network (EEN) will be extended to additional third-country markets to facilitate business cooperation, technology transfer, knowledge transfer and research project cooperation for SMEs, with the environment, renewable energy and sustainable construction as the most important sectors.

**7. KEY ACTORS IN THE ENERGY TRANSITION**

To expand Europe’s leadership position in renewables and capitalise on the energy-efficiency-first principle to reach the objective of a competitive low-carbon economy, the Commission commits to applying the policy levers described in this Communication. However, to ensure uptake of the innovative solutions that will be supported by the Commission, thereby creating sustained impact, citizens, cities, regions and Member States play a crucial role.

Citizens are central to the successful uptake of low-carbon innovative solutions, from smart meters in their homes to large-scale wind farms. Finding new and better ways to involve Europe’s citizens in the low-carbon transition and to give voice to existing high levels of popular support is of critical importance. More involved citizens take greater responsibility for their own and the EU's energy security, and they help devise novel and original business models. The emergence of energy 'prosumers' and renewable-energy cooperatives (REScoops) is a good example. In 2015 there were more than 2,500 such cooperatives in Europe, investing in better insulation, solar water heaters, or solar-
photovoltaic panels (PV panels). Thus-empowered consumers are able to act collectively and make more autonomous energy choices.

Citizen forums and dialogues are a further indispensable tool that needs to be promoted; so are associations where citizens come together to pursue shared energy-related goals. Furthermore, the energy transition must present a fair deal to all groups in society. Citizen inclusiveness is critical to facilitate the changes, create ownership of the process and ensure that all groups will be able to evenly benefit from the transition.

Regions and urban areas are most suitable for testing and implementing integrated innovative solutions in direct connection to citizens. Building on the specific support to regions and cities of the EU's regional policy, the Urban Agenda for the EU, the Global Covenant of Mayors, the European Innovation Partnership on Smart Cities and Communities, and the CIVITAS network, Europe's cities, towns and regions have been instrumental in promoting ownership of the energy transition and in pushing climate and energy-related innovation from below. In addition, networks of neighbourhoods, cities and regions will help to share best practices and pool resources and investments. In this respect the support provided through the smart specialisation platforms and Horizon 2020 for smart and sustainable cities, needs to be expanded to incorporate inclusive city aspects to further develop the results achieved. Initiatives such as the H2020 Smart and Sustainable Cities focus area, the Joint Programming Initiative (JPI) Urban Europe and Urban Agenda for the EU as well as the European Innovation Partnership (EIP) for Smart Cities and Communities, should be systemically connected, expanded and scaled-up in order to stimulate the further development and uptake of Low Carbon Energy Efficient solutions across all sectors of urban society. Better measurement and sharing of data, as well as the development of more interoperable systems and associated data security and privacy guarantees, is critical for this to take place.

Through their established innovation-linked urban eco-systems ('smart cities'), investment platforms to aggregate small-scale energy-efficiency or renewable-energy projects, and work towards more eco-friendly urban transport solutions cities are indispensable to support the uptake of clean energy innovations that are promoted through the actions of this Communication.

In addition to cities and regions, Member States are crucial in advancing the energy transition. Various mechanisms exist to coordinate the EU's energy-related research and innovation activities with those of its Member States, or to better align public-sector support with that provided by the private sector. Yet, there is room for more efficiency and for realising greater synergies.

The Strategic Energy Technology (SET) Plan, which includes 28 Member States and four associated countries, as well as industrial and academic stakeholders, is a core part of the governance structure of the Energy Union. Coordinating their respective activities and

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creating greater synergies, the SET Plan has facilitated a doubling of annual total R&D investment in SET Plan priority technologies in the past few years. Joint research and innovation targets have been set in ten priority action areas, to further step up coordinated or joint investments, reflecting a growing level of commitment. Analogously, in transport, the Strategic Transport Research and Innovation Agenda (STRIA) is being set up, structured around the development of seven expert roadmaps and a corresponding governance mechanism to support and speed up research, innovation and deployment. Both the SET Plan and STRIA will provide important structures for coordination with the actions described in this Communication, supporting their implementation and creating synergies to achieve impact.

### Key actors in the energy system - Proposed actions:

- The Commission will work with Member States through the Energy Union governance structures, particularly the SET Plan, to align Member State investments under the four priority areas mentioned in Section 5 and to establish a list of Projects of Common European Interest.

- The Commission will set up a specific governance structure with Member States on STRIA, to align strategic plans for long-term transport research and innovation actions and to better link them to the energy sector and digital technologies.

- The Commission will provide further support for the energy transition through the Smart Specialisation Platforms, as well as through developing public procurement for cities and regional tendering. A special focus will be given to support carbon-intensive regions.

- The Commission will stimulate sharing and upscaling of best practices and smart, sustainable and inclusive urban demonstration projects, including those supported under the European Innovation Partnership on Smart Cities and Communities. This will also draw on data from the European Commission’s Copernicus programme for Earth observation.
ANNEX

ANALYSIS OF THE FOUR TECHNOLOGY FOCUS AREAS

a) Energy storage solutions.

To facilitate and enable the transition to a low-carbon energy system (including transport) based largely on renewables, the EU needs to accelerate the full integration of storage devices into the energy system, at domestic, commercial and utility scale.\textsuperscript{20} Batteries and storage applications – both mobile and stationary – are crucial for e-mobility in the short-term but play a larger systemic role for RES integration and optimisation of operations. Research in this area will open the way for subsequent industrial production, the promotion of new business models and further cost reductions, yielding large potential benefits for the EU in terms of growth and jobs.

Re-launching the production of battery cells in Europe is essential: it has multiple benefits in terms of industrial competitiveness, know-how in advanced manufacturing, security of supply and Europe’s share in global value chains. Cheaper, lighter, safer and higher-performing batteries, together with faster charging solutions, are a key requirement for a shift to full electro-mobility, as well as for increasing energy storage capacities in homes (with associated benefits for grid stability and flexibility). The initiative will also include research on materials; hard- and software management, control and integration of storage devices into the energy system; linking smart electricity grids and vehicle batteries and advanced manufacturing techniques. It will improve the performance and reduce the cost of power electronics necessary to keep storage system efficiencies at a competitive level. It will also address the creation of favourable market conditions for increased dissemination of storage solutions at both consumer- and grid level, including building bridges between the electricity grid, natural gas grid and the transport system as a precondition for a fully renewables-based power supply. It will put particular emphasis on new waste streams from energy transition (batteries, solar panels, etc.), in line with circular-economy principles.

b) Electro-mobility and a more integrated urban transport system.

Based on advanced battery designs and new powertrains, next-generation electric vehicles are firmly embedded in innovative re-charging infrastructures and solutions. The development of cheaper, lighter, safer batteries with longer ranges, as well as faster and more customer-friendly technologies and charging solutions, therefore constitute priorities for research and innovation in the transport area, as well as potential competitive advantages for the EU’s transport industry. Digitisation to enable connected and automated transport and smart mobility services, currently at the demonstration stage to address technical and legislative challenges, will provide further opportunities.

\textsuperscript{20} Current EU support for storage-related R&I is provided mainly as part of the smart-grids activities of the SET Plan and in the context of the Fuel Cells and Hydrogen Joint Undertaking.
The Strategic Transport Research and Innovation Agenda (STRIA) has developed a first long-term strategic approach to prepare the envisaged change of the transport system through research and innovation combining innovative low-carbon technologies, connected and automated transport and smart mobility services, making use of new technologies such as the European global navigation satellite systems (Galileo and European Geostationary Navigation Overlay Service – EGNOS). It also identified the need for enablers and framework conditions, notably infrastructure, public acceptance and greater attention to users’ needs. The move towards more autonomous and connected transport – particularly in urban areas – and the transformation of mobility into a service and better door-to-door logistics are necessary conditions for achieving greater levels of efficiency and decarbonising the transport system.

Fragmentation in the developing new market of low-emission transport technology must be tackled and the scale-up of deployment of innovation should be supported through different policy levers (e.g., revision of the regulations setting greenhouse gas emission performance standards for cars and vans, review of the Clean Vehicles Directive), financial levers (such as EIB finance) as well as a dedicated platform approach to better share information and align action on investment.

c) Decarbonising the EU building stock by 2050: From nearly-zero energy buildings to energy-plus districts

The EU’s building stock represents a total floor area of around 25 billion m². Buildings consume 40% of the EU’s final energy demand, more than any other sector. But buildings also represent a large energy-savings potential and once renovated and upgraded, they can help to generate surplus power or provide key energy storage capacity. Transforming the EU’s building stock will yield a better living environment, create new jobs and growth and help achieve the circular economy’s objectives. To reach these goals, there is a pressing need to at least double current building renovation rates (which at only 0.4-1.2% are far too low)\(^\text{21}\) and for deeper and more thorough renovations, drawing on forward-looking legislation, standards, innovative technologies and business models, and the development of new skills and competences.

To create significant impact, innovative solutions must go beyond today’s nearly-zero-energy designs. They should address all technical aspects (including domestic renewable-power generation, energy-efficient designs for optimised life-cycle use of energy and materials, digital management and control systems, and energy-system integration) as well as regulatory, standard-setting, financing, governance and other socioeconomic issues. They must demonstrate the feasibility of energy-plus districts in different climatic regions and economic contexts, encompassing the integrated management of related environmental issues (such as water and waste).\(^\text{22}\)

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\(^\text{21}\) Around 75% of the EU’s building stock is very energy-inefficient. Following current renovation rates, it would take about a century to upgrade it to the latest standards.

d) Integration of renewables (RES).

Further system integration and developing the next generation of renewable-energy technologies, including potential game-changers, is required for renewables to become the dominant source of primary energy production and power generation. It is also prerequisite for transformation of carbon intensive sectors, such as transport, where strong incentives to innovate in alternative energies (like advanced biofuels) are needed. This includes dedicated research and innovation support, in close collaboration with industry, for Europe to maintain its global leadership in renewable-energy technologies.

Support will focus on: (1) Accelerating the development of renewable energy solutions for buildings, such as Building-Integrated Photovoltaics (BIPV) for energy generation and renewable technologies for heating and cooling, to allow the mass-realisation of nearly-zero energy buildings; (2) Research on optimisation and cost reduction of renewable energy generation, in particular for off-shore wind energy systems in order to accelerate the potential for wind deployment; and (3) Intensifying the development of solutions to increase the integration of renewables, in particular of variable renewables, into the energy system including the transport sector, through thermal and chemical storage (power-to-gas, power-to-liquids).

Greater synergies between renewable-energy production, distribution and consumption will empower consumers – citizens, communities and businesses – and encourage the deployment of novel services that cater to their changing needs and preferences, while at the same time increasing the flexibility of the system so as to incorporate large volumes of distributed, variable renewable energy.

In particular, this concerns market replication and efficient system integration of more mature technologies (e.g. wind energy and photovoltaics), in combination with energy storage or other advanced solutions, such as digital integration with electro-mobility and smart networks, to accommodate the progressive deployment of fluctuating renewable-energy sources. Cost-competitiveness and efficiency improvements of less mature, dispatchable renewable-energy technologies (e.g. flexible hydropower, ocean and geothermal energy, concentrated solar power or sustainable bioenergy), as a means to provide low carbon base-load and backup power, also need to be accelerated.

The integration of smart, cutting-edge digital technologies into all aspects of the energy system, along with their various applications, is a precondition for remaining at the forefront of the shift to the more consumer-centric products and services model that will drive the next wave of innovation in the renewable-energy sector, in storage solutions, in e-mobility, in advanced housing and in the whole of the energy sector.

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