DISCUSSION PAPER MAY 2018

INNOVATION IN EU ELECTRICITY GRIDS
LINKING RESEARCH AND INNOVATION TO DEPLOYMENT INSTRUMENTS

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Innovation in areas such as advanced transmission and distribution technologies, smart grids, and digitalisation can assist a more rapid and cheaper transition to a zero-emission energy system. To have sufficient impact, the speed at which innovations reach mass deployment (the lab-to-market cycle) must accelerate.

The bulk of grid investment in Europe is funded via regulated tariffs. This means national regulators and regulatory frameworks are the biggest determinants of how swiftly innovative technologies and approaches progress to widespread adoption.

But EU policies and funds can also be designed to have greater impact for accelerating grid innovation. Electricity grids are already a significant focus of EU-funded innovation. Meanwhile, other EU funding mechanisms support deployment of new energy infrastructure through grants and loans. However, it is often unclear how the EU's innovation and deployment strategies fit together.

This paper reviews the landscape of electricity grid innovation needs, EU funding structures for grid innovation and EU deployment support for grid innovation. It argues that there is still considerable scope for the connections between EU innovation and deployment funds to be improved. This requires reassessing infrastructure priorities and definitions (which can constrain innovative approaches), as well as updating the rules on how deployment incentives are designed.

Decarbonisation driving system change and innovation

The EU's climate change objectives have moved from incremental to transformational across the energy system: there is widespread recognition of the need to achieve deep decarbonization by mid-century. This shift will have wide-ranging implications for EU energy infrastructure. The mid-century net-zero objective leaves little room for use of unabated fossil fuels, while the role of electricity widens to decarbonise more sectors. Radical increases in renewable energy pose a system balancing challenge, with electricity interconnection and 'smart grids' acting as a key flexibility resource.[1]

Innovation background

Although 'research and innovation' is used as a catch-all term for technological developments – including in the Commission's own directorate general 'DG Research and Innovation' – the two are not the same. **Research** – and more broadly, research and development (R&D), is a process of learning and increasing knowledge. **Innovation**, on the other hand, is the actual development of new products, services, or business models using that knowledge that are deployed commercially and make it to markets. It is therefore about product creation and deployment, rather than just the invention of a new product itself, for its own sake.[2]

A key feature of innovation and innovative products is also their disruptiveness to the current system, though their development and route to market can be aided by changes in policy. In Europe's electricity system, innovative technologies are having a disruptive effect as part of broader policies on decarbonisation, renewable energy promotion, and market integration.

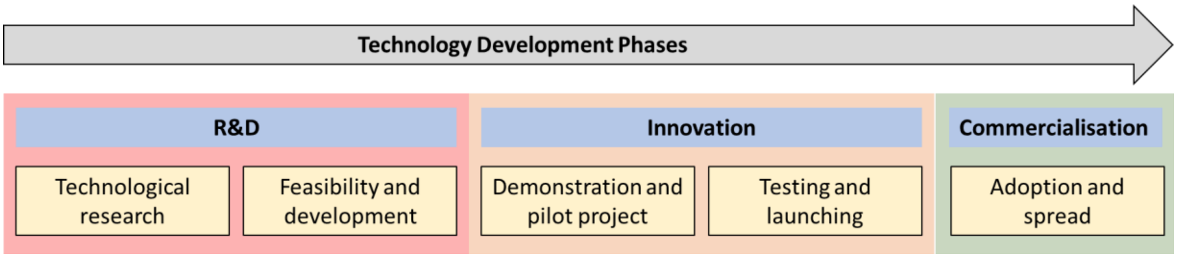

Figure 1: technology development pathway[3]

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[1] European Climate Foundation (2010), **Roadmap 2050**; E-Highway 2050 (2015), **Europe's future secure and sustainable electricity infrastructure**

[2] **http://lexicon.ft.com/Term?term=innovation**

[3] Adapted from Imperial College: **http://pathwaytoinnovation.co.uk**

Electricity grid innovation: three major shifts

As the pursuit of decarbonisation induces energy system change, the types of technology and infrastructure being deployed evolves, along with the way on which we understand the role existing infrastructure will play. As shown in figure 1, below, the electricity system of the future will be structurally different from the current one, shifting from a linear structure (‘generation to consumption’), to a more multidirectional one, with electricity flowing in multiple directions, and more distributed electricity generation.

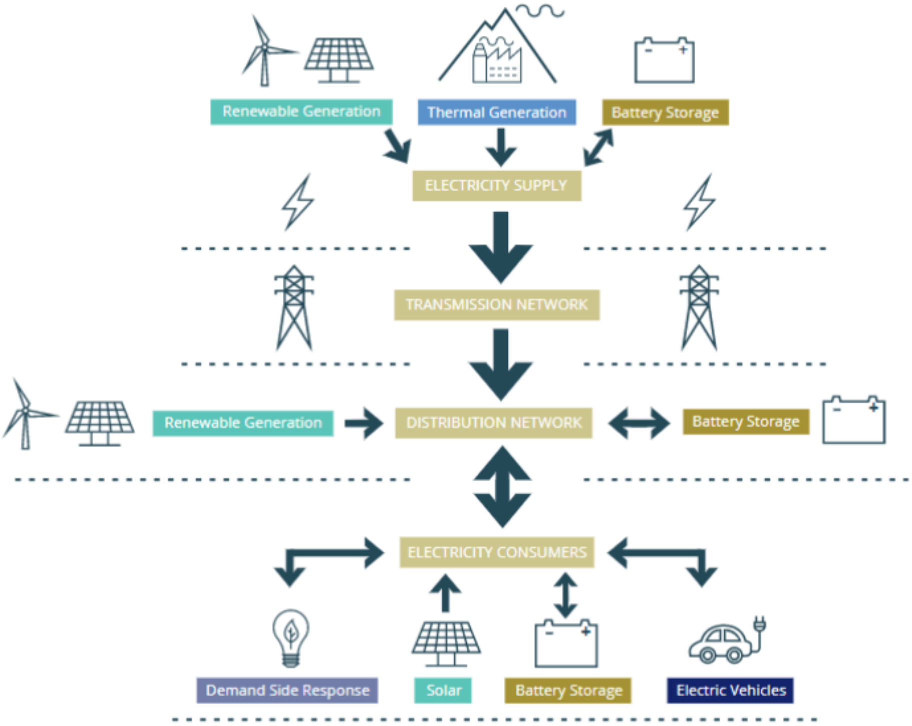

Figure 2: future electricity system

Distributed generation is crucial for decarbonisation because the renewables are the primary electricity source at this level (although there are some fossil fuels such as small gas turbines). As a result, new infrastructure solutions are required, and existing infrastructure will need to be used in a different way. This paper focuses on three primary areas of system infrastructure innovation: **grid scale infrastructure; smart grids**; and **digitalisation**. All three are areas where change new challenges require innovative infrastructure; they are simultaneously at different scales within the energy system, yet inextricably linked.

Despite the growth of decentralised generation and the shift away from baseload, **grid scale infrastructure** remains integral for EU electricity supply and the physical linking of markets in the single energy market. But they will have a changing role as decarbonisation progresses and the electricity system becomes more multidirectional.

Digitalisation is occurring at all levels of the electricity sector, from generation through to distribution and consumption. The next step of grid technology and infrastructure will be the 'digital step', enabling smart technology at all grid levels, not just distribution. As well as being a category of innovation itself, it also enables change and allows for the development of smart grids and distributed electricity generation. As such, it is a link between different levels of an electricity grid and sits underneath grid scale and smart grid innovation.

Grid scale infrastructure

Although there is a shift towards decentralised and distributed energy in the EU, grid-scale infrastructure remains a key component of the future energy system. As EU electricity networks become more integrated and complex with the development of a pan-European system[4], so innovative infrastructure and system management technologies are required. Increased volumes of cross-border electricity as well as greater levels of intermittent and decentralised electricity generation are key to future EU policies and decarbonisation, but these present technical challenges. **Despite innovative technologies being deployed at grid level, their visibility can often be limited as they are components of a wider system.**

In Europe the grid-scale innovation priority is for the integration of new technologies for generating electricity (mainly from renewable resources) and technology to allow for the increased levels of cross-border flows of electricity between member states. The primary development at grid scale has been the growth of **HVDC (high voltage direct current) connections.** These are fundamental to the completion and eventual functioning of the pan-European electricity market because they allow separate AC electricity systems in member states to be linked, and they offer much more efficient transmission across longer distances. These connections are either long-distance **HVDC interconnectors** (often subsea), or as **'back-to-back' connections** which link AC systems on either side of a border without any intervening transmission infrastructure.[5]

HVDC connections are also becoming increasingly relevant for the development of offshore wind farms, particularly in the North Sea. Windfarms close to shore use AC connections, but the locations of new, bigger windfarms further out to sea means HDVC connections are used to reduce transmission losses as they are more efficient. This means deploying them as 'generator-to-market' connections as well as more traditional 'market-to-market' connections.

A key innovation in this area has been the development of **HVDC circuit breakers**. The use of HVDC lines is traditionally limited to 'point-to-point' connections (such as subsea interconnectors) and not integrated grids, where AC is used. Where the two

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[4] **https://ec.europa.eu/energy/en/topics/infrastructure/developing-european-energy-grid**

[5] **http://www.un.org/esa/sustdev/publications/energy/chapter2.pdf**

meet the current is converted. But the different electrical properties of DC current means circuit breakers for AC current cannot be used, and until recent years the technology for DC circuit breakers did not exist.[6] But their development now means mean HVDC can be used on grids themselves, and not just to connect separate ones.[7]

The increased penetration of intermittent generation means solutions are needed to manage the of operation networks that were previously designed for dispatchable baseload electricity supply, but now have lots of renewables. With wind and solar, for example, their intermittency and lack of inertia can affect system stability. The range of tools are known as **ancillary services**. These include fast reserve, short-term operating reserve (STOR), demand management, and frequency response. These all provide a way for system operators to maintain system adequacy, supply and stability if there are unscheduled or atypical changes to supply and demand, or if weather-related generation (i.e. solar and wind) is different to what had been forecast.

Case study: meshed offshore grids

The development of offshore windfarms is traditionally with individual point-to-point connections to shore, but in regions such as the North Sea, there are financial, technical, and environmental benefits to coordinating the development of wind farms and connections to develop a **meshed offshore grid**. This would see several neighbouring wind farms clustered together, with these clusters connected to offshore hubs that are in turn connected to each other and to various countries.[8] The electricity generated at the windfarms would be moved via AC cables to offshore convertor stations, from where HVDC connections would take it ashore.[9] Developing a meshed HVDC grid allows for greater interconnection of decentralised renewables generation with electricity grids, across longer distances. A meshed grid development brings together HDVC interconnection, circuit breakers, VSC, as well as innovative wind farm design (such as bigger blades and turbines in deeper water depths).

Smart grids

Smart grids are networks that can automatically monitor energy flows and adjust to changes in energy supply and demand accordingly.[10] The way in which electricity systems work is fundamentally changing because of the shift away from centralised, dispatchable, baseload supply generation (mainly via transmission networks), to renewable electricity generation, with most at a distributed generation level. But as electricity generation becomes more localised and more intermittent with increasing

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[6] https://brage.bibsys.no/xmlui/bitstream/handle/11250/2383177/14132_FULLTEXT.pdf?sequence=1

[7] http://new.abb.com/grid/events/cigre2014/hvdc-breaker

[8] https://ec.europa.eu/energy/sites/ener/files/documents/2014_nsog_report.pdf

[9] https://www.tennet.eu/news/detail/tennet-presents-solutions-for-increasing-the-scale-of-wind-energy-on-the-dutch-north-sea/

[10] https://ec.europa.eu/energy/en/topics/markets-and-consumers/smart-grids-and-meters

renewables, there is a greater need to reconfigure networks. This requires developing smart grids, which are electricity networks that allow two-way communication between suppliers and consumers, responding to changes in supply and demand. Key benefits of smart grids include:

- More efficient transmission of electricity
- Reduced operations and management costs for utilities
- Smoother electricity demand peaks
- Integration of both large-scale and embedded renewables[11]

Smart grids also allow for **sector coupling**, understood as the converging energy use of the three principle energy consuming sectors of transport, industry, and buildings. In the EU, this is being driven by decarbonisation and decentralisation of energy, as the electrification of transport, heating and – where possible – industrial processes lowers energy consumption. **The co-development of generation, distribution, and storage infrastructure across sectors can help to exploit synergies and avoid oversupply of infrastructure**. For example, rolling out smart grids allows electricity to become more distributed, with the use of smart meters and increased use of electric vehicle charging.

Case study: Smart WindFarm conTrol (Swift) project, Belgium

The Swift project at the Port of Antwerp aims to demonstrate how to maximise windfarm integration in to distribution grids while minimising the amount of lost wind energy at the lowest possible overall cost. The electricity grid in the port region is heavily congested because of high power industry at the port, so smart grid technology was deployed an alternative to reinforcing or expanding the grid.[12] The project used three smart grid technologies, which use the real-time monitoring and control of electricity production and consumption to allow for more flexible use of existing grid infrastructure at the port. Technologies deployed include dynamic line rating[13] (DLR), active network management (ANM), and demand-side management (DSM).

Digitalisation

The increasing use of digital operations and system management enables a shift away from centralised fossil-fuel power generation to more decentralised and intermittent renewable generation. Electrification of the energy system and transport, with

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[11] https://www.smartgrid.gov/the_smart_grid/smart_grid.html

[12] https://www.etip-snet.eu/wp-content/uploads/2017/04/ETP-SG-Digital-Energy-System-4.0-2016.pdf

[13] Using data about physical and electrical properties of a power system to improve its transmission capability, meaning the system capability can respond quickly and safely – see Morozovska, K, & Hilber, P., Study of the monitoring systems for dynamic line rating, *Energy Procedia*, 105 (2017) 2557-2562

decentralised generation and consumption, require management of electricity grids that allows flexibility and responsiveness to less-predictable supply and demand. Digitisation and the use of data and communication allows grid operators to work and respond with near real-time response to supply and demand fluctuations. **This means that in some cases deploying digital systems, as software, can replace investment in physical (hardware) infrastructure**. Digitalisation has three core elements:

- **Data**: collection of digital information
- **Analytics**: the use of data to produce useful information and insights
- **Connectivity**: exchange of data between humans, devices and machines through digital communications networks[14]

As well as integrating renewables, digitalisation can also help reduce overall electricity demand, as the co-development of smart distribution grids can help integrate storage and EVs into the electricity system. Both can be used for local demand management and developed alongside embedded electricity generation – such as rooftop solar – and connected to distribution networks. In future, the planning and development of grids will need investment in networks, as well as in cross-border interconnectors to allow the import and export of electricity with other countries.

The two-way communication between different elements of the network, and between electricity suppliers and consumers, allows grid operators to respond in real-time to supply and demand fluctuations.[15] And with more coordinated operations, smart technologies can respond to local electricity supply and demand. This allows the development of smart grids, and the integration of the transport, building, and industrial sectors. More broadly, digitalisation of energy end-use sectors, such as industry, buildings, logistics and transport, has the potential to enable deep changes in the manner that energy is consumed, with the potential for radical improvements in energy efficiency.[16]

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[14] http://www.iea.org/publications/freepublications/publication/DigitalizationandEnergy3.pdf

[15] https://www.siemens.com/global/en/home/company/topic-areas/sustainable-energy/grids.html

[16] The IEA estimates widespread digitalisation could lead to 10 PWh of energy savings in Europe's building sector by 2040. IEA (2017), Digitalisation and Energy

Case study: Engie Darwin digital data platform

The Darwin digital platform enables Engie to collect and analyse data transmitted via sensors installed at its renewable electricity generating plants. Information collected includes wind turbine rotation speeds, photovoltaic panel temperatures, and electricity outturn. This is then used with external data such as electricity market prices and weather forecasts to allow more efficient and cost-effective generation and maintenance scheduling. The data is also shared with consumers and local communities. All of Engie's solar plants, wind farms and hydropower plants in France, Belgium, Italy, Germany, Poland, the Netherlands and Romania use the platform, while its global windfarm and solar portfolio will have the platform by 2019.[17]

Infrastructure deployment financing

After the development of the new directives and regulations of the 2009 Third Energy Package[18] which had the aim of creating single EU markets for gas and electricity, the Commission detailed its future energy infrastructure priorities in a 2011 communication. This document informed the **Trans-European Energy Networks** (TEN-E) regulation of 2013, which set out three 'priority corridors' for infrastructure investment (by geographic region, in electricity, gas, and oil), and three secondary thematic areas (smart grids, electricity highways and CO2 networks). It sets out the 'guidelines for the timely development and interoperability of priority corridors and areas of trans-European energy infrastructure'. To increase investment in these areas the TEN-E regulation established the **Connecting Europe Facility** (CEF) to provide to "fill the missing links in Europe's energy, transport and digital backbone".

Under TEN-E, new infrastructure aligned with the priority corridors and meeting certain criteria can be designated as a **Project of Common Interest** (PCI), making them eligible to receive funding for design, preparatory and early-stage construction work from the CEF, as well as accelerated licensing procedures and improved regulatory conditions. Projects need to meet at least one of the following general criteria:

(i) involves at least two Member States by directly crossing the border of two or more Member States;

(ii) is located on the territory of one Member State and has a significant cross-border impact;

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[17] **https://www.engie.com/en/news/darwin-big-data-growth-lever-for-renewables/**

[18] Directives on rules for the internal gas (2009/73/EC) and electricity markets (2009/72/EC); regulations on access to the natural gas transmission networks ((EC) No 715/2009), cross-border electricity networks ((EC) No 714/2009), and for the establishment of ACER ((EC) No 713/2009)

(iii) crosses the border of at least one Member State and a European Economic Area country. [19]

Specifically, in the electricity sector projects must also meet one or more of the following criteria:

(i) market integration

(ii) sustainability and integration of renewables

(iii) security of supply and system operation[20]

CEF and innovation

In the CEF regulation, new technologies and innovation is one of the four explicit 'horizontal priority' categories for transport projects, in line with TEN-T regulation which requires the EU transport network to 'keep up with innovative technological developments and deployments' in pursuit policy and operational aims such as decarbonisation and increasing passenger safety.[21] A transition to innovative low-carbon transport is a sectoral objective for transport, **but no such requirement or sectoral objective exists for energy**.

Under the TEN-E regulation electricity projects meeting the criteria for PCI designation with regards to each geographic priority corridor (annex 1) and technical characteristics (annex 2) are also eligible for additional financial assistance in the form of grants for works if they fulfil additional criteria, set out below.

(a) the project specific cost-benefit analysis provides evidence concerning the existence of significant positive externalities, such as security of supply, solidarity **or innovation**;

(b) the project shall aim to provide services across borders, **bring technological innovation** and ensure the safety of cross-border grid operation;

(c) the project is commercially not viable according to the business plan and other assessments carried out, notably by possible investors or creditors or the national regulatory authority.

However, this is for additional funding and is secondary to meeting one or more of the requirements listed above on the basic functioning and characteristics of a project

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[19] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32013R0347

[20] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32013R1316

[21] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32013R1315

Grid scale infrastructure

The manner in which the PCI process favours of mature technologies is reflected in how, overall, most PCI funding goes to grid scale natural gas projects. To date there have been three PCI lists complied, with natural gas and electricity projects dominating in terms of number of designated projects and total value. Changes in project categorization – notably in 2017 – mean direct year-on-year comparison between the lists is difficult, as several gas projects have been clustered together rather than removed from the list.

However, it has been suggested by the Commission that the fall in the number of gas projects was because of a better recognition of the EU decarbonisation goals, improved methodology in the selection process, and a new focus on the most urgent and needed projects. **But the number of non-grid level projects (such as smart grids) in the PCI list may not reflect the success of PCI process as it designed with as focus on cross-border infrastructure.**

Smart grid development

Although smart grids can qualify for PCI status and receive money from CEF, only a very small number of these projects have been designated as PCIs across the three lists; and to date, only one has received funding as an action. A key reason for this is that the eligibility criteria of the TEN-E regulation are arguably too restrictive for smart grid projects in general and are not inclusive of innovation at the distribution system or distributed energy level because of the criteria, detailed above, that they need to meet.

There are also technical requirements for smart grid eligibility, including being across high-voltage and medium-voltage levels (above 10 kV); involve transmission and distribution system operators from at least two member-states; cover least 50,000 users (generation and/or consumption); and cover a consumption area of at least 300 GWh/year, of which at least 20% originate from variable renewable resources.[22]

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[22] https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/assessment-framework-projects-common-interest-field-smart-grids

Sincrogrid Project, southeast Europe

The Sincrogrid project between Croatia and Slovenia is the only smart grid project to have been funded under the PCI process to date, having applied in 2015. The project builds on long-standing cooperation and technical integration between the two countries going back to the 1970s when their first cross-border grid connection was built. The countries currently have seven transmission lines connecting them.

The project involves TSOs and DSOs for both countries and addresses several shared technical challenges that are putting their grids under pressure, such as increasing levels of renewables, falling electricity consumption, less centralised power generation (with more decentralised renewables), and higher cross-border flows with neighbouring countries. But these issues are not unique to Croatia and Slovenia in Europe, being central issues that smart grid technology is designed to address.

Sincrogrid received PCI status because of the cross-border element, although a lot of its technical features are at the domestic transmission or distribution grid level. **Across Europe DSOs are the main driving force behind smart grid development, rather than TSOs or other actors such as utilities and electricity generators. This underlines that the CEF and PCI process are not adequately designed for smart grids.**

Although smart grid development is recognised as a means of contributing to sustainable development and is a priority thematic area, **the focus on integration of markets and interoperability of cross border networks favours large-scale and more-mature technologies.**

CEF energy and transport synergy call

In 2016 the Innovation and Networks Executive Agency (INEA) opened a call for projects that bring together and contain elements across the transport and energy sectors, with a total budget of €40 million. Of the seven successful projects, two were for electricity and one smart grids (with four for natural gas): [23]

- **TSO 2020**: develop electricity storage solutions and alternative transport infrastructure, known as ‘power-to-gas’, through creating and supplying hydrogen in the Netherlands and the western part of Germany.[24]

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[23] https://ec.europa.eu/inea/sites/inea/files/c_2017_2612_f1_annex_en_v4_p1_883786.pdf

[24] http://tso2020.eu/

- **SYNERG-E:** link electricity transmission and storage with transport infrastructure, by installing ten test battery storage systems in Austria and Germany before installing high power electric vehicle charging stations.[25]
- **Smart grid project (*unnamed*):** optimising the electricity power supply for railways in Croatian from the transmission network, to make it more energy efficient.

Despite the synergy calls, the design of them is problematic. Typically, investments in different sectors (for example, transport and energy) are made at different time scales, meaning they do not match up. Furthermore, the main driver behind this, sector coupling, is relatively undeveloped in practice.

Innovation financing and regulatory incentives

Significant levels of investment are required in European electricity infrastructure to ensure the completion of the internal energy market and decarbonisation. Though TSOs can raise equity or borrow for these works, it is also important that national regulators develop regulatory frameworks that allow companies to generate enough revenue to remain financially viable. National regulators in member states set 'regulatory incentives' that ensure policy or operational objectives, such developing new infrastructure, innovation, or sustainability, are met in line the with policy aims.[26]

This helps to reduce the level of risk associated with some infrastructure investments, although there needs to be a balance between the interests of consumers and infrastructure developers. Innovative technologies, such as smart grids, may cost more money than current infrastructure, which could affect deployment and take up. Infrastructure projects are typically funded and regulated in two ways: merchant model or the regulated model.

The **regulated model** is where the TSO invests in and operates the infrastructure as a regulated asset, and costs are recovered through customer transmission charges. Under the **merchant model** private companies develop and operate the infrastructure to get a commercial return – but they are exposed to the full risk of their investment. Because consumers do not underwrite the cost of development, the investment decision is made by the developers and not the TSO. This means it may not be as policy focused as infrastructure developed under the regulated asset mode, although under EU regulation investors still need to gain permission from the national regulator.[27]

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[25] **http://www.synerg-e-project.eu/**

[26] Glachant, J M., (et al), 'Incentives for investments: Comparing EU electricity TSO regulatory regimes', Florence School of Regulation research report (2013)

[27] Dutton, J, & Lockwood,M., Ideas, institutions and interests in the politics of cross-border electricity interconnection: Greenlink, Britain and Ireland, *Energy Policy*, 105 (2017) 375-385

Using innovative technology on infrastructure projects comes with extra levels of risk compared to more mature technology, which means it can be difficult to deploy under a merchant model. Risk include higher operating expenditure (Opex), costs of capital expenditure (Capex), operational experience, and expected revenue.[28] **This means more needs to be done by policy makers to ensure the right innovation is being undertaken**, and to demonstrate the long-term case for deployment over a short term simple investment case.

Using the regulated model can allow national regulators to fund innovation through raising tariffs, which would also reduce the financial risk for companies deploying innovative technologies. **Although the deployment of innovative technologies is done so with the approval of national regulators, irrespective of EU policies, there is scope to use the regulated asset base and TSO revenues to expand innovation funding.**

Strategic Energy Technology Plan (SET Plan)

The EU's strategy for energy technology innovation is set out in its Strategic Energy Technology Plan (SET plan), while the principal EU-level funding instrument for research and innovation is the Horizon 2020 programme. This is supplemented by further innovation funding via Cohesion Policy and national budgets. Key energy research and innovation instruments include European Structural and Investment Funds (ESIF), NER 300 for innovative low-carbon energy demonstration projects, European Fund for Strategic Investments (EFSI) and the European Investment Bank (EIB).

The Commission published a communication in September 2015 setting out a new energy research and innovation strategy, building on its initial 2007 Strategic Energy Technology (SET) Plan. This new integrated plan was built around the Energy Union strategy and highlighted which areas the EU needs to strengthen cooperation across member states and stakeholders "**to bring new, efficient and cost-competitive low-carbon technologies to the market faster and in a cost-competitive way**."

To increase cooperation and implement the SET plan, nine European Technology and Innovation Platforms (ETIPs) were created to promote the market uptake of energy technologies by pooling funding, skills, and research facilities. The SET plan acts as the reference point for European, national, regional and private investment, and it defines priorities across the entire energy system through one consistent agenda at EU level from research to market uptake. Among the nine[29] ETIPs is Smart Networks for Energy Transition (SNET), as well as various low-carbon electricity sources.

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[28] **https://ec.europa.eu/energy/sites/ener/files/documents/MJ0614081ENN_002.pdf**

[29] Bioenergy, Wind, Deep Geothermal, Ocean energy, PV, Renewable Heating and Cooling, Sustainable Nuclear Energy (SNET), Zero Emission Fossil Fuel Power (ZEP)

ETIP SNET

The ETIP for grid innovation, Smart Networks for Energy Transition (ETIP SNET), has informed a series of roadmaps – the most recent covering the 2017-2026 period – which set out the long-term research and innovation targets for the evolution of the European energy system. The purpose of the roadmap is to address system flexibility by considering several options for both transmission and distribution level, including sector coupling, flexible thermal and renewables generation, storage, and digitalisation. Within the roadmap, work is divided into a number of clusters at both transmission and distribution grid levels.

Transmission Clusters	Distribution Clusters
C1 – Modernisation of the network	**C1 – integration of smart customers and buildings**
C2 – Security and system stability	**C2 – Decentralised network integration**[30]
C3 – System flexibility	**C3 – Network operations**
C4 – System economic efficiency	**C4 – Planning and asset management**
C5 – Digitalisation	

Figure 3: ETIP SNET 2017-2016 clusters[31]

Horizon 2020

The Horizon 2020 research and innovation programme includes a specific fund for energy as part of the Societal Challenges work programme, which was created to support the SET Plan. It has budget of €5.93bn for non-nuclear energy research across the 2014-2020 period, with around €200mn earmarked for the European Institute of Innovation and Technology in Budapest.

The work programme for "Secure, Clean and Efficient Energy" is split into the following areas: **energy efficiency; low carbon technologies;** and **smart cities and communities.** This research programme was shaped by the revision and development of the new SET plan, as above with ETIP. Above all, the research programme is structured around specific objectives and research areas in-line with EU climate and energy goals, including a single, smart European electricity grid, and better market uptake of energy and ICT innovation.[32]

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[30] Transmission C3 and Distribution C2 include generation, storage, demand and networks

[31] **https://etip-snet.eu/pdf/Final_10_Year_ETIP-SNET_R&I_Roadmap.pdf**

[32] **https://ec.europa.eu/programmes/horizon2020/en/h2020-section/secure-clean-and-efficient-energy**

Project case study: EUROSUNMED

The project's aim is to develop new technologies in three areas: photovoltaics, concentrated solar power, and grid integration. It also aims to promote the production and trial of components in hot, dry and testing conditions, with a view to eventual deployment in the Mediterranean region.

Project case study: NOBEL GRID[33]

The project is developing tools and ICT software for the electricity market – including cooperatives and local communities – to ensure lower energy prices, more secure and stable electrical grids, and clean electricity. It has designed three grid management tools, including two smart meters being tested in Belgium, Greece, Italy, Spain and the UK.

Pilot projects and demonstrators can be funded through instruments such as Horizon 2020, but this does not cover the commercial-scale deployment which is crucial for innovation. A technology may already be at the post-innovation stage, but risk perception among investors and project developers can prevent investment decisions in new technology.

Linking innovation and deployment: recommendations

The gap between EU funding of infrastructure innovation and infrastructure deployment needs to be closed

Electricity grid innovation is crucial for the future energy system of the EU, but there is a disconnect with deployment of new technologies required to reach the policy aims of decarbonisation. Most innovation is done at the national regulatory level, but the EU needs to look at its own policies to help close the gap.

Although there are a range of innovation funding instruments that are developed in line with the overarching EU aims on decarbonisation and more specific ones of the Energy Union, the deployment of these technologies does not always occur at the same scale as more mature, established technologies. The EU's deployment policies on energy network infrastructure do not specifically incentivise the innovative technologies and techniques developed by these programmes. This is a missed opportunity for EU spending to assist with the deployment of innovative technologies, rather than funding research alone.

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[33] **https://ec.europa.eu/programmes/horizon2020/sites/horizon2020/files/lc_booklet.pdf**

How infrastructure is defined and understood needs to evolve

There needs to be a change in how we define infrastructure, particularly in relation to digitalisation and the perception of policy makers and system operators. The nature of infrastructure and how we want it to operate is changing, but current policy frameworks do not best address this. Future planning will not be a binary choice between the current business as usual and innovation, but rather there will be a combination of technologies at different scales and provision of different services, with different cycles for innovation and infrastructure.

As part of this, there needs to be recognition in policy that there are different project lead-in and development times for software compared to physical infrastructure. There is also an issue with differing life cycles, with typical CEF projects and PCIs lasting for multiple decades whereas digital systems and ICT could be superseded and require replacement in under ten years. Regulation needs to be redesigned to address this shift in infrastructure time scales.

Furthermore, Europe needs a new regulatory framework that allows new innovations such as ancillary services on the electricity grid to be able to receive funding and generate revenue in the way ‘traditional’ infrastructure does, with the monetisation of new technologies. There is an ongoing technical transition in grid and system design, but one is also required for policy makers and system planners.

There need to be more specific incentives for innovation in the TEN-E

Under the TEN-E regulation additional funding is available for PCIs if they demonstrate that the project can bring technological innovation, or the cost-benefit analysis shows innovation is one of the project’s ‘positive externalities’. But a requirement for innovation should be included within the main eligibility criteria for PCI status, and not just for additional finance. As part of this, the TEN-E and CEF regulations should be amended to include a requirement or sectoral objective of using innovative technology, as is currently the case with transport in the regulations. This would act as a ‘pull’ mechanism for the deployment of innovative technologies. This can also alleviate some of risk for investors by providing an EU-wide framework for using new technology in major infrastructure projects.

The criteria for PCI status under the TEN-E regulation should be changed to be more supportive of innovation and new technology

The technical criteria for electricity projects gaining PCI status are too restrictive to encourage the take up and inclusion of innovative technology. This is most clear with smart grids, where requirements such as involving multiple members and minimum voltage levels mean most smart grids will not be eligible for PCI status. The dominance of grid scale electricity project in the PCI list innovation reflects this, even though the PCI process was not designed to promote smart grids or innovation. But with smart grids already included as a thematic priority area, the TEN-E regulation can better utilised to encourage the deployment of smart grids and innovative technologies.

About E3G

E3G is an independent climate change think tank operating to accelerate the global transition to a low carbon economy. E3G builds cross-sectoral coalitions to achieve carefully defined outcomes, chosen for their capacity to leverage change. E3G works closely with like-minded partners in government, politics, business, civil society, science, the media, public interest foundations and elsewhere. In 2018, E3G was ranked the third best environmental think tank in Europe, and fifth best in the world.

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