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MAKE REGULATION FIT FOR INNOVATION

HOW EU REGULATIONS CAN ENABLE INNOVATIONS FOR A CLIMATE NEUTRAL ECONOMY

MARION BACHELET
Associate JDEC Research Fellow

THOMAS PELLERIN-CARLIN
Director and senior research fellow, Jacques Delors energy Centre, Paris.

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Executive summary

This June, the European Commission, led by President von der Leyen, will present an overhaul of the European Union (EU) buildings, energy, industry and mobility regulatory frameworks. This so-called 'Fit for 55 package' is the litmus test of the European Green Deal.

This policy paper attempts to understand how this major EU legislative initiative can help deliver the clean energy innovation needed to avoid a climate disaster. To do so, this paper builds on a review of 30 academic articles. Based on this research, it concludes that **regulation is a very powerful tool to stimulate innovation**. The European Commission should therefore use its 'Fit for 55' **proposals to boost the creation, testing, scale up and deployment of clean energy innovation**. To do so, it should:

- Build a **political narrative** that emphasises the key role of those regulations to boost the **innovations** that will help Europe reach **climate neutrality** by 2050.
- Set clear, ambitious, and binding objectives for specific sectors. Such objectives should provide innovators and companies **time to adapt and experiment**, and leave them **flexibility to find the best solutions** to comply with ambitious targets.
- Propose directives and regulation that **accelerate the phase-out of polluting technologies, whenever clean alternatives are available**.

INTRODUCTION

"I believe in innovation, not in punishment, not in bans, not in regulatory frameworks, for climate change". This statement encapsulates a key debate among current European policy makers on how to address climate change. Some present innovation as an alternative to regulatory frameworks.[1] Others fear that an innovation agenda would be a distraction from regulatory actions.[2] Both positions implicitly consider that EU regulations cannot boost innovation.

Yet, when listening to innovators, investors and business leaders in the clean energy sectors, we hear a very different opinion. Many indeed emphasise **the importance of regulation to boost clean energy innovation**. They argue for instance that "the regulatory framework is critical for success in clean technology. Without political effort, you cannot make the change. It has to be the first step."[3] or conclude that "policy is a very powerful force to stimulate innovation (...) because it forces change".[4]

To resolve this regulation-innovation conundrum, this policy paper starts with a first section that introduces key definitions that are referred to later on. Sections 2 and 3 build on a literature review of 30 academic articles to understand how past regulations have succeeded or failed to boost incremental and breakthrough innovations in the buildings, energy, industry and mobility sectors. Section 4 finally provides the policy recommendations and concrete examples on how the European Commission can propose EU legislation, like the CO2 emissions standards for cars regulation, the Alternative Fuels Directive, or the Energy Performance of Buildings Directive, that better supports clean energy innovation.

1. "I believe in innovation, not in punishment, not in bans, not in regulatory frameworks, for climate change, which is why establishing a Horizon programme which invests in technology capable of solving problems –[is] what we need to do" is the full sentence of a statement made on 15 May 2019 by Manfred Weber, the then European Popular Party candidate for the presidency of the European Commission, during one of the major televised debates between the six lead candidates (Spitzenkandidat) of the six major European political families. Source: Kelly E. 2019. "Pacesetter in EU presidential race says tech innovation should be main response to climate change", *Sciences Business*, 16 May.
2. Pascal Canfin, during a public debate organised in Paris by the Jacques Delors Institute and the Réseau Action Climat on 16 April 2019, said that "I do not think that climate change is a matter for innovation. We already have all the solutions today (...) and when we connect the green transition with an innovation agenda, there is always the risk of letting think that we don't have the solution, that we need to re-invest and see again in five years or ten years." Authors' translation from French. Full statement is available here.
3. Full quotation by Ivo Nemejc, Investment Director at Inven Capital: ""The regulatory framework is critical for success in cleantech. Without political effort, you cannot make the change. It has to be the first step. We see it in hydrogen and electric mobility: strong policy moves result in market uptake." It can be found in the Clean Tech Group's Cleantech for Europe March 2021 Report.
4. Francesco Starace, CEO of ENEL, at the April 7th 2021 joint Brunswick and Europe Jacques Delors webinar said the following sentence "The importance of this is underestimated. I think policy is a very powerful force to stimulate innovation. And it's often encountering resistance from existing industries and established systems, because they force change. But that is largely necessary, for the better."

1 ▪ A EUROPEAN POLICY FIT FOR CLEAN INNOVATION IS CRUCIAL TO DELIVER CLIMATE NEUTRALITY

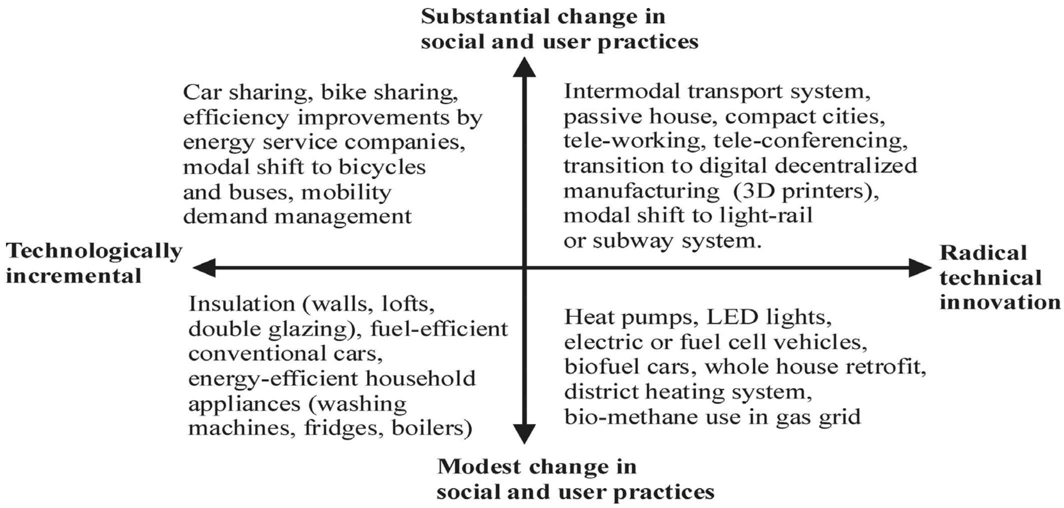
1.1 ▪ Defining innovation: introducing valuable changes to the energy system

There is a rich academic debate on the several ways to define innovation[5]. Building on definitions by the OECD[6] and academics[7], we hereby define innovation as the action of introducing something new to a given organisation. For innovation to be beneficial, this 'something' must be useful and valuable, and is not always something new to the world.[8] While many innovations have negative impacts on the environment –such as the recent shift towards Sport Utility Vehicles (SUVs)–, this paper focuses only on the innovations that increase humankind's chances to avoid a climate disaster.[9]

Technologies and techniques, and how they are used by humans, play a key role in the wider socio-technical transformation required to drastically reduce greenhouse gas emissions that are the root causes of the ongoing climate change.[10] One recurring way to approach the technological dimension of innovation is to assess the technological readiness of specific technologies (see Box n°1), to understand to what extent the policy effort should focus on developing new technologies (*e.g.* to produce green steel), or on developing the enabling infrastructure, policies and user practices that will trigger the deployment of already technologically mature solutions (*e.g.* heat pumps for residential heating).

5. For a deeper discussion on the definitions of innovation, *cf.* Baregheh A., Rowley J. & Sambrook S. 2009. "Towards a multidisciplinary definition of innovation", *Management Decision*, 47:8, pp. 1323-1339.
6. "An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations." OECD & Eurostat. 2005. *Oslo Manual*, 3rd edition.
7. "Innovation is the process of making changes, large and small, radical and incremental, to products, processes, and services that results in the introduction of something new for the organization that adds value to customers and contributes to the knowledge store of the organization" in O'Sullivan D. & Dooley L. 2009. *Applying Innovation*, Thousand Oaks, CA: SAGE Publications, Inc. p.5.
8. Research differs from innovation. Research is the process of creating ideas, processes, technologies, services or techniques that are new to the world. It usually distinguishes between basic research (*e.g.* discovery or invention# of a new material/idea) and applied research (*e.g.* trying to apply this new material/idea to a specific sector).
9. IPCC. 2018. *1,5°C Report*.
10. Geels F.W., Schwanen T., Sorrell S., Jenkins K. & Sovacool B.K. 2018. "Reducing energy demand through low carbon innovation: A sociotechnical transitions perspective and thirteen research debates", *Energy Research & Social Science*, 40, pp. 23-35.

FIGURE 1 ▪ Variety of low carbon innovations with different degrees of social and technical novelty



Source: Frank W. Geels, Tim Schwanen, Steve Sorrell, Kirsten Jenkins, Benjamin K. Sovacool, "Reducing energy demand through low carbon innovation: A sociotechnical transitions perspective and thirteen research debates", Energy Research & Social Science, 2018

Within this overall definition, different types of innovation impacts can be distinguished. Based on the typology set by Henderson and Clark[11], we can categorise four types of innovations depending on their impacts on individual components and the overall architecture of a product or a process:

1. **Incremental innovations involve smaller improvements in individual components.** In the car industry, one example is the improvement of the efficiency of internal combustion engines that have become more efficient over the past decades.
2. **Modular innovations involve additions to, or substantial changes in, the core design** concept of one or more component(s), but do not change the way a technological system links together. One example is the catalytic converter which reduces the emissions from an internal combustion engine, and could be added to conventional vehicles without changing their basic architectures.
3. **Architectural innovations involve the reconfiguration of existing components into a new product architecture.** An example of this is the hybrid-electric powertrain, which does not incorporate any fundamentally new component technologies, but combines them in new and different ways.
4. **Breakthrough innovations involve substantial changes in components as well as product architecture**; battery electric vehicles are an example of this: they replace internal combustion engines with electric motors, driveshafts with cables and fuel tanks with batteries.

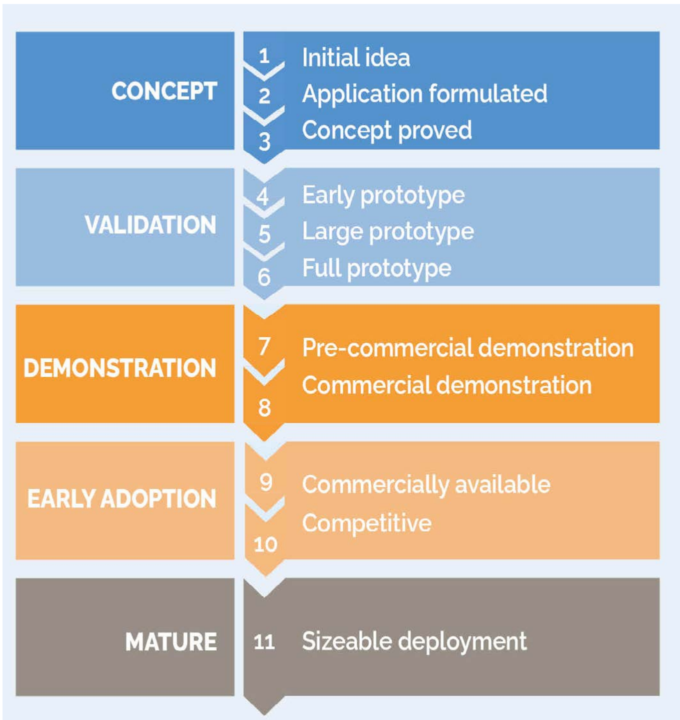
11. Henderson R.M. & Clark K.B. 1990. "Architectural innovation: the reconfiguration of existing product technologies and the failure of established firms", *Adm. Sci. Q.*, 35, pp. 9–30.

BOX 1 ▪ Presenting the technology readiness level (TRL) scale

To assess the degree of maturity of a technology along the innovation process, the International Energy Agency (IEA) uses an extended version of the technology readiness level (TRL) scale[12]. The TRL was developed by the NASA in the 1970s. The EU also now uses it to assess projects funded as part of its research and innovation policy. The scale provides a common framework to assess and compare the maturity of technologies across sectors. Along five main phases of the technology development process, the TRL scale distinguishes 9 stages (from TRL 1 to TRL 9), plus 2 additional stages defined by the IEA (TRL 10 and TRL 11).

1. At the **concept phase**, the technology moves from TRL 1, where its basic principles are defined, to TRL 2 where its concept and application are formulated. Then it moves to TRL 3 when the concept has been proved through experiment. Lithium-air batteries and electrifying a steam cracker for olefins production are examples[13].
2. The technology then enters a **phase of validation** with the development of a prototype (TRL 4). Battery-electric aircraft and direct electrification of primary steelmaking are examples of these small prototypes. The prototype is then tested in the conditions in which it will be deployed (TRL 5-6). Ammonia powered vessels, electrolytic hydrogen-based steel production and direct air capture of carbon dioxide (DACCS) are examples of these large prototypes.
3. Next, the technology moves to the **demonstration phase**. It is tested in a real-world environment (TRL 7) before reaching commercial demonstration (TRL 8). Electrolytic hydrogen-based ammonia and methanol, and large long-distance battery-electric ships are examples.
4. Then comes the early **adoption phase**, where the technology is commercially available in the relevant environment (TRL 9). However, at this stage, the technology still needs to be further developed to be integrated within existing systems or evolve to be able to scale. For this reason, the IEA has extended the TRL scale to incorporate two additional levels of readiness. In the early adoption phase, the technology goes through an additional stage where it is commercial and competitive but needs further innovation efforts for its integration into energy systems and value chains when deployed at scale (TRL 10). Offshore wind, electric cars and heat pumps are examples.
5. Finally the technology reaches the **mature phase** where it has achieved a sizable deployment and for which only incremental innovations are expected (TRL 11). Hydropower and electric trains are examples.

FIGURE 2 ▪ The technology readiness levels scale, applied to clean energy innovation



Source: own elaboration, based on International Energy Agency, Energy Technology Perspectives, 2020

12. IEA. 2020. *Energy technology perspectives*.
13. Examples are taken from *Energy technology perspectives*, 2020, IEA.

This typology implies that for an environmental policy instrument to have an impact on innovation, it should stimulate either incremental, modular, architectural and/or breakthrough changes in a product or process.

The modelling and understanding of innovation processes[14], as well as their management has changed over time (*cf*. Box 2). Nowadays, analysis recognises the role of regulations, as regulations shape markets and the markets are seen as a key element informing the research and innovation activity of companies (esp. in the market-pull model, and other models that focus on this role of markets). By adopting clear, enforceable regulations with a long-term perspective, policy makers can indeed send clear signals to markets and innovators, and thus promote innovation in specific areas and sectors.

1.2 ■ Research and innovation are critical to achieve climate neutrality

Since the Climate Paris Agreement, a new target for climate policy is to reach climate neutrality. Becoming 'climate neutral' means not only reducing greenhouse gas emissions to low levels, but also compensating for any remaining emissions. Compensation can occur via various offsetting measures, such as reforestation. A climate neutrality target (net-zero greenhouse gas emissions, including carbon dioxide, methane etc.), is more ambitious than a carbon neutrality target, as the latter only tackles one specific greenhouse gas: carbon dioxide (net-zero CO_2 emissions).

This new climate neutrality objective is a drastic change from previous international objectives. In the 1980s and 1990s, climate targets only aimed at a rather slow and modest decline in greenhouse gas emissions (for instance, a "freezing of carbon emissions, with a reduction of 20 percent by 2005"[15]). By contrast, as Bill Gates recalls in his latest book, reaching climate neutrality is feasible, but very hard.[16] It indeed requires innovation at a scale and at a speed never seen before in the energy world –but at a scale that we saw in other moments in history (such as the world wars) or in other sectors (such as the digital revolution). A recent report from the IEA underlines that reaching climate-neutrality requires a massive innovation effort[17]. The report focuses on the IEA's sustainable development scenario, which sets out the major changes that would be required to reach global net-zero CO_2 emissions by around 2070. According to this scenario (*cf*. Figure 4), almost 35% of the cumulative carbon dioxide (CO_2) emissions reductions achieved by 2070 come from technologies that currently are at large prototype or demonstration phase (TRL 4 to TRL 8, *cf*. Box n°1).[18] Around 40% come from technologies that, such as wind power or electric cars, have not yet been commercially deployed on a large scale (TRL 9 to TRL 10).

14. In the European debate, the innovation process is often characterised as a 5-steps cycle: research, development, demonstration, deployment and maturity. For a recent example, *cf*. i24c and Capgemini Consulting, Scaling up innovation in the energy union to meet new climate, competitiveness and societal goals, 2016.
15. Rich N. 2018. "Losing Earth", *New York Times Magazine*.
16. Gates B. 2021. *How to Avoid a Climate Disaster*. Bristol: Allen Lane.
17. IEA. 2020. *Energy technology perspectives*.
18. The contribution of technologies at large prototype or demonstration stage to emissions reductions is even higher in heavy industry and long-distance transport, where commercially available and scalable options for achieving deep emissions reductions are currently limited.

BOX 2 ▪ Defining innovation process modelling: past and present

Roy Rothwell identifies five model generations[19], which could be complemented by the open innovation paradigm introduced by Chesbrough[20]. While those models appeared successively in the academic literature (*cf.* figure 3), they have co-existed until today in both academic writing, policy and business decisions. For instance, the EU seeks to impact energy innovation through elements inspired from different models *e.g.* specific Horizon Europe calls are inspired by the technology-push model, the EU CO2 standards for cars is inspired by the demand-pull model, while the European Institute of Innovation and Technology (EIT) is inspired by the Networking model.

The first model is a simple linear **technology-push model** created in the 1950s. Research & Development (R&D) is seen as the beginning of the innovation process (the idea generation and the conception of the innovative service or product), followed by the production and marketing.

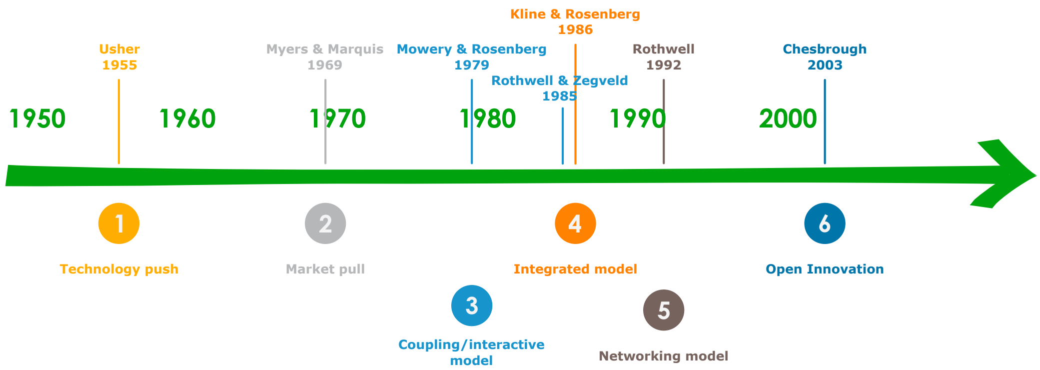
As market competition grew throughout the 1950s and 1960s, it became more important to consider consumer needs. This led to the **market-pull model**, also called **demand-pull model**. This model is also linear, but it reverses the direction of the previous model: it is now the market that informs R&D. From this perspective, as regulations shape the market, regulations influence companies' research and innovation efforts.

Then came the **coupling model**, that essentially couples technology-push and market-pull. This model starts by considering the linkages between the various functions of a company, as well as linkages outside the company, and feedback loops in the innovation process.

To overcome the linear approach of the first three models, the **Integrated Model** considers innovation to be the result of complex interactions (inside a given company, and between the company and its environment), with markets becoming both the beginning and the end of the process.

This paved the way for the fifth generation, a **Networking model**, driven by a need to increase the efficiency and shorten the life cycle of the innovation process. It looks at collaboration and linkage between people inside and outside a company, through the involvement of upstream and/or downstream to co-develop innovation, or through the establishment of consortia, alliances and other forms of partnership. Putting a more important emphasis on flexibility, interactivity and interconnection, Henry Chesbrough proposed the **open innovation model**[21], and the term 'open innovation' is now mainstream in the EU policy debate[22].

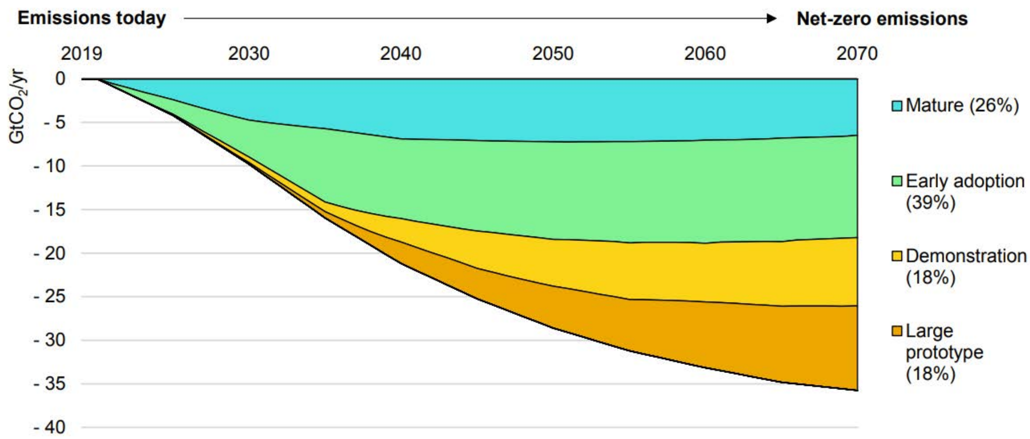
FIGURE 3 ▪ Timeline of the apparition of the main innovation models, with founding authors



Source: Pellerin-Carlin T. & Serkine P. 2016. "From distraction to action for a bold European energy union innovation strategy", policy paper, Jacques Delors Institute, 14 June, p. 5.

19. Rothwell R. 1994. "Towards the fifth-generation innovation process", *International Marketing Review*, 11:1, pp. 7-31.
20. Chesbrough H. 2006. "Open innovation: The new imperative for creating and profiting from technology". Cambridge: Harvard Business Press.
21. There is no consensus among academics whether to consider open innovation as a new generation of model or as a feature of the networking model.
22. For a discussion on the open innovation model from an EU perspective see Gabison G. & Pesole A. 2014. "An overview of models of distributed innovation", *JRC Science and Policy Reports*.

FIGURE 4 ■ Global energy sector CO2 emissions reductions by current technology maturity category in the Sustainable Development Scenario relative to baseline trends, 2019-70



Source: IEA, Energy technology perspectives, 2020

Finally, EU innovation policy constitutes one of Europe's greatest contributions to global climate action. Indeed, the 27 member states of the European Union together represent 5% of global population, 10% of global greenhouse gas emissions, 15% of global GDP but 25% of the global scientific publications[23]. Achieving climate-neutrality in Europe is laudable, necessary, but insufficient by itself. **By using its diplomatic, economic and innovative strengths, Europe goes way beyond decarbonising its own economy: it leads the way and inspires other countries to do so, and reduces the costs of the transition for others.** It thus helps to reduce emissions around the world. In this regard, clean energy innovation is of critical importance as the rest of the world can import, or take inspiration from EU innovations.

1.3 ■ Policy intervention is necessary to encourage clean energy innovation

The innovation process of energy technology is affected by market failures at all stages of development. Without policy intervention, companies structurally underinvest in clean energy innovation. The major market failures are[24]:

1. **Knowledge market failures.** In most cases, new technologies must be made available to the public for the inventor to reap the rewards of invention in the process of patenting and copyrighting. By making new inventions public, some of the knowledge embodied in the invention becomes public knowledge. This public knowledge may lead to additional innovations, or even to copies of the current innovations. These knowledge spillovers provide

23. These figures are based on the following sources and calculation: 5.77% of the global population according to Eurostat for EU 27 population in 2020 & Country meters for global population in 2020, 9.47% of global greenhouse gas emissions based on EEA estimates for EU27 GHGs in 2019 and JRC Edgar report 2020 estimates for global GHGs in 2019, 16.14% of global GDP according to World bank data for EU27 in 2018, and 23.37% of all world's scientific articles, based on data from the National Science Foundation for EU27 in 2018.
24. Rennings K. 2000. "Redefining innovation: Ecoinnovation research and the contribution from ecological economics", *Ecological Economics*, 32:2, pp. 319–332.

benefit to the public as a whole, but not to the innovator. As a result, **private firms do not have incentives to provide the socially optimal level of research activity**. Knowledge spillovers are particularly large during the basic and applied research stages of innovation. While this market failure is not specific to environmental innovation, the literature on that field of study has focused on additional knowledge market failures, such as path dependency and capital market failures. Policies addressing knowledge market failures are often referred to as technology-push policies. Direct government funding of research projects are examples of such policies.

2. **Environmental externalities.** Firms and consumers have little incentive to reduce pollution as long as it is not sufficiently costly to pollute. Without appropriate policy interventions, the market for technologies that reduce emissions will be limited, reducing incentives to develop such technologies and further slowing commercialisation. To address these environmental externalities, policies are used to increase the potential market size for clean energy innovation. These policies are often referred to as demand-pull policies in the literature. Carbon taxes or cap-and-trade systems, such as the European Union Emissions Trading System (EU ETS), provide a strategy to address this type of market failure[25].

Beyond this, **clean energy innovation requires targeted public support because it is riskier than innovation in other sectors**[26]. To understand this, one can compare it with pharmaceutical and software innovation[27]. All are affected by a 'technology risk' (i.e. will my technology work?), and by a 'market risk' (i.e. will my innovation find its customers?), but in a different manner:

A. Pharmaceutical innovation is characterised by a high technology risk and a low market risk. For instance, developing a cure to COVID entails a high technology risk (i.e. will this cure actually work on humans, and with which side effects?). It however has a low market risk as a cure to COVID will find customers.

B. Software innovation is characterised by a low technology risk and a high market risk. For instance, the technology needed to build a mobile phone app is straightforward. This new app may however never find a market due to irrelevance or competition.

C. **Clean energy technological innovation combines both a high technology risk and a high market risk**. For instance, a green hydrogen company faces a high technology risk: will it be able to cheaply produce hydrogen from renewable electricity? It also faces a high market risk: will it find a market if alternatives (*e.g.* natural gas, grey hydrogen, blue hydrogen, direct electrification) are more competitive?

1.4 ▪ Regulatory instruments are important in the policy mix

To tackle these market failures, regulators have two types of instrument:

1. **Economic instruments** (also referred to as **priced-based instruments**) aim at **providing actors with incentives** to adopt low-emission technologies, such as economic compensation corresponding to the avoided social cost of pollution. Actors who invest in a

25. Lehne J., Moro E, Nguyen P.V. & Pellerin-Carlin T. 2021. "The EU ETS: from cornerstone to catalyst. The role of carbon pricing in driving green innovation", E3G & Jacques Delors Institute, 20 April.
26. Pellerin-Carlin T. 2019. 'Invest in the clean energy future we want –ten recommendations to accelerate competitive clean energy innovation with Horizon Europe', Jacques Delors Institute, January.
27. Gaddy B., Sivaram V. & O'Sullivan F. 2013. "Venture Capital and Cleantech: the wrong model for clean energy innovation", *MIT Energy Initiative Working Papers*, July.

polluting technology will need to pay the economic cost of their pollution. Firms are therefore expected to undertake pollution control efforts out of their own economic interests.

2. **Regulatory instruments** (also referred to as **direct regulation or command and control**) shape markets and firms behaviours, for example via technological standards (i.e. prescription of a certain method, equipment or technology), emission standards (an absolute upper emission level), and performance standards, such as a cap on emissions per unit of output. Other types of regulatory instruments include bans or prescribed use of certain solutions and permits for building and operation of plants. These regulations can be compulsory or optional (firms can choose whether or not to comply, but non-compliance may come with a penalty or other negative consequences).

Instruments working through the price mechanism offer incentives for private actors to develop improved technologies[28] and make it attractive for firms to clean up more than mandated if feasible technologies are available[29]. Higher energy prices encourage innovation on alternative energy sources and on some energy-efficiency technologies. When facing higher fuel prices, firms in the automotive industry tend to innovate more in cleaner technologies, such as electric and hybrid cars, and less in fossil-fuel technologies that improve internal combustion engines[30].

But prices alone do not encourage sufficient innovation. It can be politically difficult to set high enough carbon taxes to induce the required innovation efforts. Moreover, the impact of price incentives on innovation can be limited in markets where buyers only carry a fraction of the actual cost of use, or cannot develop alternatives themselves (*e.g.* the common car buyer cannot develop an electric car or a public transportation system by him/herself). In the construction sector, owners renting out their property are not the actual end-users and do not carry the cost of use, and thus the penalty of poor insulation[31]. Instead, building code changes are necessary to induce innovation for home energy efficiency. Prices are particularly ineffective for inducing innovation on less-visible technologies such as insulation that are installed by builders and that are not easily modified. Similarly, in the automotive sector, the life-time value of a more efficient product exceeds the perceived value for the first customer who only includes the savings during the first 2–3 years at the time of their buying decisions[32].

Regulatory policies offer a wide range of tools to tackle market failures. As barriers differ depending on the stage of the innovation process[33], one challenge is to choose the adequate regulatory instrument adapted to the maturity of the innovation (Box 1). We focus on policies implicitly or explicitly aiming at the development, commercialisation, early adoption of new technologies (including further performance enhancement and process develop-

28. Requate T. 2005. "Dynamic incentives by environmental policy instruments –A survey", *Ecological Economics*, 54:2-3, pp. 175-195.
29. Bergquist A. K., Söderholm K., Kinneryd H., Lindmark M. & Söderholm P. 2013. "Command-and-control revisited: environmental compliance and technological change in Swedish industry 1970-1990", *Ecological Economics*, 85, pp. 6-19. . Jaffe A.B., Newell R.G. & Stavins R.N. 2002. "Environmental policy and technological change", *Environmental and Resource Economics*, 22, p. 41.
30. Aghion P., Dechezleprêtre A., Hemous D., Martin R. & Van Reenen J. 2016. "Carbon Taxes, Path Dependency and Directed Technical Change: Evidence from the Auto Industry", *Journal of Political Economy*, 124:1, pp. 1–51.
31. Noailly J. 2012. "Improving the energy efficiency of buildings: the impact of environmental policy on technological innovation", *Energy Economics,* 34:3, pp. 795-806.
32. Greene D. 2010. "Why the Market for New Passenger Cars Generally Undervalues Fuel Economy", Joint Transport Research Centre Round Table, Paris: OECD/International Transport Forum, 18–19 February.
33. Oosterhuis F. H., Kuik O. J. & Berkhout F.G.H. 2007. "Innovation dynamics induced by environmental policy: Final report", *IVM Report*, E-07/05, Instituut voor Milieuvraagstukken.

ment), rather than on policy instruments directed only at the early phases of discovery and invention (*e.g.* R&D support schemes). We also include diffusion policies, *e.g.* instruments directed at further adoption of already commercially available solutions.

At the early stage of development (TRL 4 to 8), innovations mostly require further technical improvements or cost reductions. Innovation-push policies can secure private investment in R&D by shaping a long-term and ambitious regulatory framework. Then demand-pull policies can take over at a more advanced stage (TRL 8 to 11), when there is lower scope for additional technical improvements and cost reductions, although higher costs compared with their conventional competitors are still a major obstacle for their diffusion. To begin scaling up emerging technologies with higher risk profiles and costs, regulatory policies can help create and shape early markets by deploying small niches. Finally, mass deployment of mature clean energy technologies can be supported by ousting polluting technologies when cleaner solutions are available.

1.5 ▪ EU regulations and the Fit For 55 Package

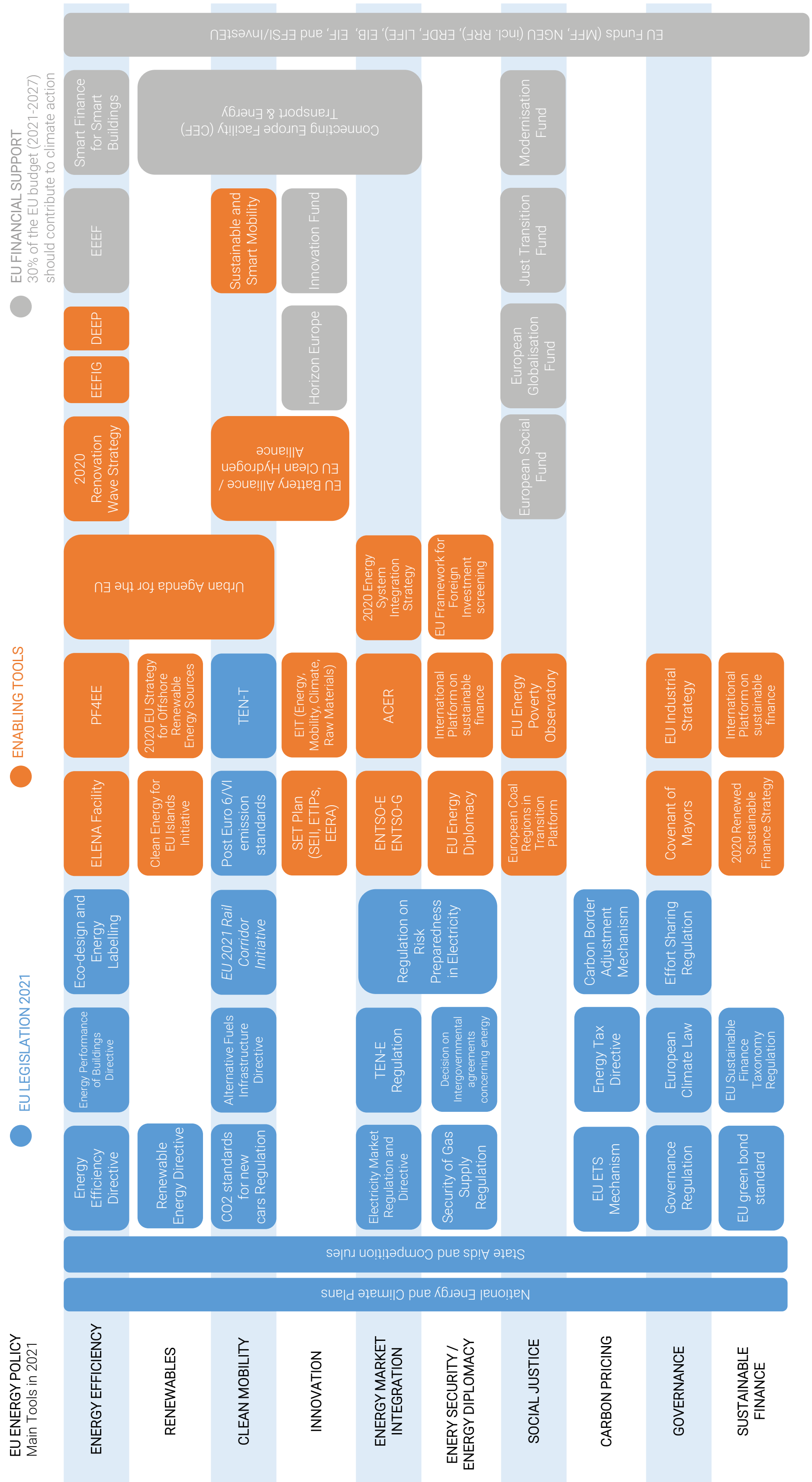
The European Union now has a comprehensive set of energy-climate policy tools, articulating EU legislation, enabling tools and financial support (*cf.* Figure 5). This results from decades of EU policy decisions. The first important set of EU legislations concerning energy started with the adoption of the so-called first energy package in 1996, followed by subsequent adoptions of new legislative packages in 2003, 2009, and 2018.

In June 2021, the European Commission will present its 'Fit For 55 Package' that will propose the creation of a few new tools (*e.g.* carbon-border adjustment mechanism[34]) and changes to key legislative elements, notably on carbon pricing, renewables, emissions standards for cars, and buildings. This constitutes a once-in-a-decade opportunity to adopt the right legislations that will increase humanity's chances to avoid a climate disaster. Not only should the EU legislation be fit to deliver a 55% reduction of EU greenhouse gas emissions by 2030, it must also be fit to create and develop in this decade the clean solutions that will be vital to continue the journey to climate neutrality after 2030.

In this policy-paper, we use the term "EU regulation" to talk about all the EU regulations and EU directives the European Union can adopt and enforce, either directly or indirectly via the legal power of EU Member States.

34. Lamy P., Pons G. & Leturcq P. 2020. "Greening EU trade 3, A European Border Carbon Adjustment proposal", Europe Jacques Delors Policy Paper, June.

FIGURE 5 ▪ EU energy policy main tools in 2021



2 ▪ AMBITIOUS AND FLEXIBLE INNOVATION-PUSH REGULATIONS CAN CREATE A MORE SECURE ENVIRONMENT FOR CLEAN ENERGY INNOVATION

2.1 ▪ A clear, precise and ambitious regulatory objective encourages breakthrough innovations at early stages of development

Stringent European environmental regulation would send a clear signal to encourage research and development of clean technologies that have the possibility of achieving economic and environmental objectives at the same time, rather than a sole research in end-of-pipe technologies.

Stringency covers both the level of ambition of environmental objectives and the effectiveness of the application of environmental regulations.

Stringent regulations encourage currently immature technologies because they increase the probability that these technologies will be needed to comply with such targets.

Lanoie and his coauthors analyse the hypothesis proposed by Porter and van der Linde relative to the role of environmental policy in promoting innovation (Box 3). The authors use a survey carried out in 2003 ans interviewing CEOs and environmental managers in facilities with more than 50 employees in various manufacturing sectors of seven OECD countries[35]. Based on a framework describing the Porter Hypothesis causality chain, they identify three dependent variables depending directly or indirectly on environmental policy: Environmental R&D, Environmental Performance, and Business Performance, in order to test the three versions of the Porter Hypothesis (weak, narrow, and strong). They find that **policy regimes perceived as "very stringent" by the companies have a positive and significant impact on the probability of having a specific R&D budget devoted to environmental issues**. These results provide strong support for the "weak" version of the Porter Hypothesis.

Comparing the EU and Japan approaches to regulate mercury emissions from chlor-alkali plants, Yarime shows that **when emission standards are not very stringent, companies focus on incremental change through end-of-pipe technologies**[36]. Lenient emission standards, like the Japanese one, gave incentives to continue using obsolete processes and thus favour technological lock-in. On the contrary, stringent regulation, like in the EU, created a strong and secure demand for clean technologies.

Timing **and commitment of the regulator are also very important.** To reinforce the signal sent by ambitious targets, the regulator must also place its policy in a long-term perspective. Vollebergh highlights the fact that companies will only continue investing in R&D and innovation if they expect a stronger stringency of the standard in the future[37]. Long-term policy

35. Lanoie P., Laurent J., Johnstone N. & Ambec S. 2011. "Environmental Policy, Innovation and Performance: New Insights on the Porter Hypothesis", *Journal of Economics & Management Strategy*, 20:3 Fall, pp. 803–842.
36. Yarime M. 2008. "Promoting green innovation or prolonging the existing technology", *Journal of Industrial Ecology*, 11:4, pp. 117-139.
37. Vollebergh H. 2007. "Impacts of environmental policy instruments on technological change", *OECD Report*.

is even more important for the energy, buildings and transport sectors because of the long lifecycle of events in those sectors. While the typical lifetimes for key digital sector assets are relatively brief (*e.g.* months/years for software and hardware), the lifetimes of most energy sector assets typically ranges from several decades (*e.g.* a power plant, steel plant or aircraft) to more than a century (*e.g.* urban infrastructure) (Figure 6).

BOX 3 ▪ The Porter hypothesis

The mainstream view among most economists, managers and policy-makers concerning environmental protection is that it comes at an additional cost imposed on firms, which may erode their global competitiveness. This is an avatar of the commonly hypothesised 'economy vs. ecology' dilemma.

Michael Porter and Claas van der Linde challenge this traditional view[38]. **They suggest that the introduction of a boundary through environmental policy can be seen as an opportunity to detect new profitable strategies**, allowing companies to improve both the environment and the economic performance. From this reasoning, they argue that "properly designed environmental regulation can trigger innovation that may partially or more than fully offset the costs of complying with them". This is known as the Porter's win-win hypothesis. In other words, it is possible that **environmental regulations encourage innovation that reduce both the environmental impact of production activities and the cost of complying with the regulation, as long as the regulation is well-designed and stringent**. Thus, stringent environmental standards lead to investment in R&D (or changes in processes, organisations, and so on), which in turn leads to innovations.

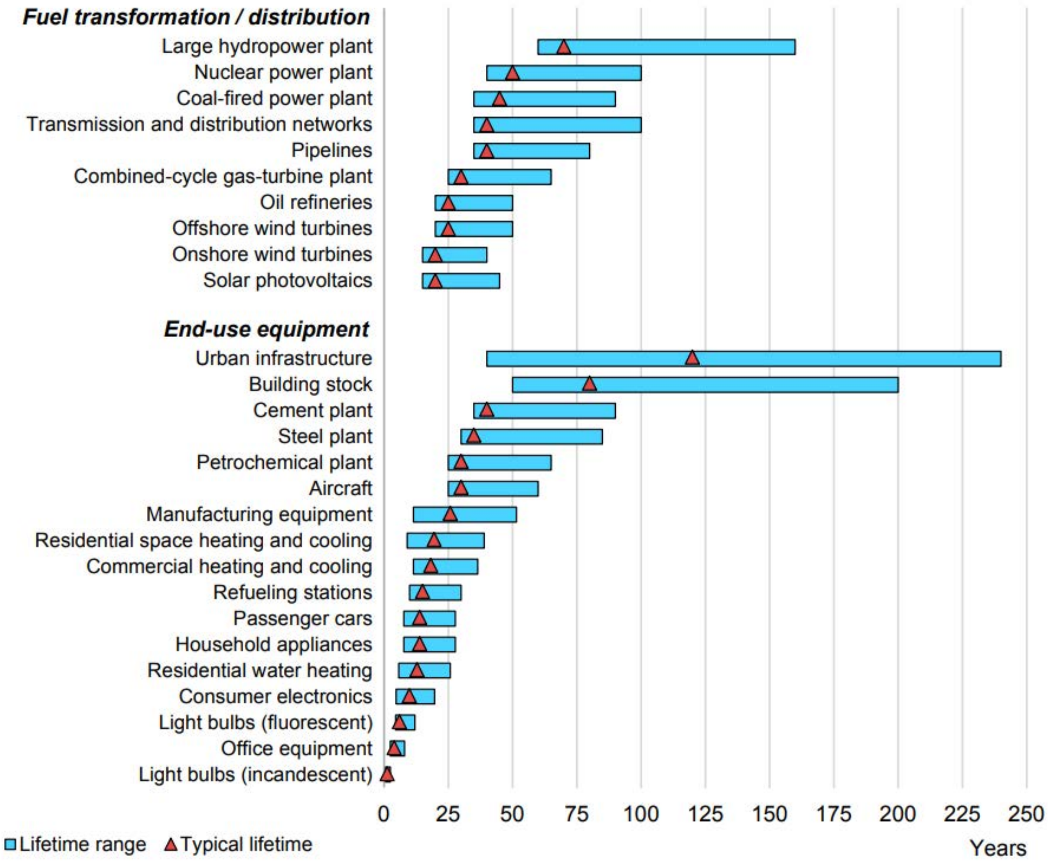
The Porter hypothesis is controversial. In a perfectly competitive economy, economists consider that if there are opportunities to reduce costs and inefficiencies, companies should identify them by themselves without the need for government intervention. Thus for the Porter hypothesis to be valid, at least one market imperfection is required in addition to the environmental externality[39]. One example of an additional market failure is knowledge spillovers (*cf.* 1.3).

Jaffe and Palmer[40] distinguish **three variants of the Porter hypothesis**:

- the "weak" version states that more stringent environmental regulations enhance innovation: because environmental policy changes the relative price (or opportunity cost) of environmental factors of production, increased policy stringency encourages companies to identify means of economizing on their use.
- the "narrow" version of the hypothesis asserts that flexible environmental policy instruments, such as pollution charges or tradable permits, give firms greater incentive to innovate than prescriptive regulations, such as technology-based standards. Flexible performance standards induce innovation by giving firms the incentive to seek out the optimal means to reduce their environmental impacts.
- the "strong" version stands that more stringent environmental policies can be commercially beneficial to the firm. Properly designed regulation may induce innovation that more than compensates for the cost of compliance and improve the financial situation of the firm.

38. Porter M. & Van der Linde C. 1995. "Toward a New Conception of the Environment-Competitiveness Relationship", *Journal of Economic Perspectives,* 9:4 Fall, pp. 97-118.
39. Ambec S. & Barla P. 2005. "Can Environmental Regulations be Good for Business? An Assessment of the Porter Hypothesis", *Energy Studies Review*.
40. Jaffe A.B. & Palmer K. 1997. "Environmental Regulation and Innovation: A Panel Data Study," *Review of Economics and Statistics*, 79:4, pp. 610–619.

FIGURE 6 ■ Typical lifetime for key energy assets, according to the International Energy Agency



Source: IEA, Energy technology perspectives, 2020

2.2 ■ Flexible regulatory instruments allow firms to find the best solutions to comply with the ambitious targets

Stringency is not the only element that contributes to the success of regulation policy. The type of policy tools used also matters. Among the instruments available, the regulator can choose between:

- **technology standards**, that specify the method or the actual equipment that firms must use to comply with a particular regulation (*e.g*. prescription of best available technology for storage of petrol at terminals and distribution to service stations), and
- **performance standards**, that set a uniform control target for firms but do not dictate how to reach this target (*e.g*. CO2 emissions standards for cars).

Technology-based standards can be problematic in inducing or forcing technological change. Indeed, once firms adopt the prescribed target technology, they often cease to have any incentive to further invest in the development of other technologies that could achieve results beyond those expected by the regulators, or could meet the same targets more efficiently or cheaply[41]. Lanoie and his coauthors point that the perceived severity of the performance standards has a more important impact than that of the technology-based standards. With respect to the "narrow" version of the Porter hypothesis, this finding that more flexible "performance standards" are more likely to induce innovation than more prescriptive "technology-based standards" supports the trend towards "smart regulation". Performance standards induce innovation by giving firms the incentive to seek out the optimal means to reduce their environmental impacts. Thus **stringent performance standards offer the right combination between enforcement and flexibility to incentive breakthrough innovation** that create major disruptive change[42], and can stimulate more breakthrough innovation than market instruments do[43]. In practice, performance standards that mandate environmental performance beyond existing technological capabilities in the industry play a role of techno-logical forcing.

Interestingly, a study[44] on the Swedish regulatory approach during the period 1970-1990 to lower emissions in the metal smelter and pulp and paper industry, concludes that regulation relying only on performance standards grants flexibility to firms in order to select the appro-priate compliance measures.

In the early 1970s and 1990s, the US federal government introduced a series of regulations through the Clean Air Act to impose a drastic reduction of vehicles' emissions. According to Lee and his coauthors[45], this performance-based technology-forcing regulations imposed on the automobile industry were associated with significant increases in innovation as measured by patenting activities[46]. Automakers decided to satisfy regulatory demand by developing the automotive catalytic converter technology rather than relying on modifying existing engine structure. This suggests that **performance-based technology forcing regu-lation is a useful regulatory tool for inducing ambitious technological change rather than incremental innovation**. **The strongest innovative reaction happened when the US Federal Government enacted the two most ambitious requirements, suggesting that stringency is indeed a key determinant of the degree of induced technological change**. Finally, policy affected innovation not only by auto assemblers, which were the firms directly regulated, but also innovation made by the upstream suppliers. This finding supports the idea that stringent

41. Jaffe A.B., Newell R.G. & Stavins R.N. 2002. "Environmental policy and technological change", *Environmental and Resource Economics*, 22, p. 41. . Popp D. 2003. "Pollution control innovations and the Clean Air Act of 1990", *Journal of Policy Analysis and Management*, 22, pp. 641–660., 2003.
42. Kemp R. 1997. *Environmental policy and technical change. A comparison of technological impact of policy instruments*, Cheltenham: Edward Elgar.
43. Kemp R. & Pontoglio S. 2011. "The innovation effects of environmental policy instruments –A typical case of the blind men and the elephant?", *Ecological Economics*, 72, pp. 28-36.
44. Bergquist A. K., Söderholm K., Kinneryd H., Lindmark M. & Söderholm P. 2013. "Command-and-control revisited: environmental compliance and technological change in Swedish industry 1970-1990", *Ecological Economics*, 85, pp. 6-19.
45. Lee J., Veloso F.M. & Hounshell. D.A. 2011. "Linking Induced Technological Change, and Environmental Regulation: Evidence from Patenting in the US Auto Industry", *Research Policy*, 40, pp. 1240-1252.
46. Research and development spendings offer a straightforward measure for innovation activities, although they do not reveal information on the output of the innovation process. Patents offer an alternative measure: they inform not only on the output of the innovative process but also on the level of innovative activity itself, as they are filed early in the research process (Griliches Z. 1990. "Patent Statistics as Economic Indicators: A Survey", *Journal of Economic Literature*, 28:4, pp. 1661-1707). However patent measures also have drawbacks. They do not reflect exactly the level of R&D, and their existence doesn't mean that the technology has been adopted. Moreover, their scope is limited by the fact that they are more likely to be used to protect new products rather than new processes (Levin R.C., A.K. Klevorick, R.R. Nelson & S.G. Winter. 1987. "Appropriating the Returns From Industrial Research and Development", *Brookings Papers on Economic Activity*. 3, pp 783-820).

environmental policy may generate a systemic response that goes beyond the focal firms affected by the regulation and includes the suppliers, which have incentives to promote their products for the new market for technology created by the regulation.

Designing emission targets that exceed current technological capabilities has proved to encourage firms to develop breakthrough innovation to meet new policy goals. However the successful implementation of technology-forcing regulations requires that regulatory agencies possess technical knowledge and capabilities with sufficient depth to establish an appropriate level of stringency. It also requires companies to have sufficient time to experiment with different solutions to comply with the new policy goals.

2.3 ■ Extended compliance periods enable companies to develop long-term breakthrough innovative solutions

There may be a trade-off between achieving quick environmental results and promoting breakthrough innovation[47]. Some environmental problems require an urgent solution. Nonetheless, some measures that allow the reduction of pollutants in the short term by encouraging the uptake of incremental innovations may discourage breakthrough and systemic innovations by leaving insufficient time to develop long-term innovative solutions. **To stimulate breakthrough innovation, EU regulation policy should give firms time flexibility to comply with stringent targets through long-term compliance periods**.

If the implementation period is not long enough, like the regulation of mercury emissions in Japan, it takes the risk of leading companies towards an inefficient use of resources, as firms are required to make large investments without a clear understanding of emerging technological options[48]. Thus, strict standards are more efficient if combined with flexible time strategies. Environmental regulations need to set an explicit mandate to phase out the existing pollution-laden technology, associated with a certain degree of flexibility in their schedule of implementation, reflecting the state of technological developments in an accurate and timely manner. The aforementioned Swedish regulatory approach to lower emissions in the metal smelter and pulp and paper industry showed that extended compliance periods are key to success[49].

With extended compliance periods, EU policy would give the opportunity to companies to experiment with different solutions before the final licence is decided. By allowing longer compliance periods, thus reducing investment uncertainty and permitting flexibility in R&D and demonstration strategies, the affected companies could accept the increased uncertainty associated with a more ambitious technology-forcing performance standard. The use of compliance periods in this way would also increase the EU regulatory system's legitimacy.

47. Kemp R. 2000. "Technology and environmental policy: Innovation effects of past policies and suggestions for improvement." Paris: OECD.
48. Yarime M. 2008. "Promoting green innovation or prolonging the existing technology", *Journal of Industrial Ecology*, 11:4, pp. 117-139.
49. Bergquist A. K., Söderholm K., Kinneryd H., Lindmark M. & Söderholm P. 2013. "Command-and-control revisited: environmental compliance and technological change in Swedish industry 1970-1990", *Ecological Economics*, 85, pp. 6-19.

3 ▪ DEMAND-SHOCK REGULATION POLICIES CAN HELP ACCELERATE THE DIFFUSION OF EMERGING AND MATURE INNOVATIONS

3.1 ▪ Create niche markets to mediate the transition of technologies from R&D to commercial scale-up

Demand-pull innovation policies give certainty on market opportunities for innovative clean energy products by creating initial market niches. This can play a critical role in helping emerging technologies achieve wider market diffusion, particularly in the energy sector[50]. In the US, nine major regulatory events occurred since the 1950s to induce technological change for the control of sulphur dioxide (SO2) emissions in electric power plants. Initially regulation took the form of performance standards (percentage reduction of emission), and from 1990 emissions per heat input were limited. This series of demand-pull policies was effective at promoting invention in environmental technology on its way to commercialization[51].

Public procurements regulations are also an efficient tool to boost innovation, including through the creation of niche markets. When the governments spend money strategically, they can act as powerful market leaders, driving change across entire industries through contracts for which private companies compete.

The EU could further[52] enable Member States to support the innovation activities in their country. The Buy Clean California Act (2019) requires contractors that bid on infrastructure projects to disclose greenhouse gas emissions data for certain materials that they plan to use, like steel, glass or mineral wool for insulation. These disclosures, called Environmental Product Declarations (EPDs), allow government purchasers to take the embodied carbon of materials into account, in turn using the states' purchasing power to influence manufacturers to reduce emissions. Such a measure requires to have adequate data on the carbon content of materials. More recently, on 27th of January 2021, US President Joe Biden issued an executive order aimed at tackling the climate crisis. It encourages federal agencies to become more environmentally conscious consumers, and to shift their spending towards clean energy and electric vehicles. Making public procurement greener can act as a catalyst for sustainable businesses, giving climate-conscious producers consistent demand from a powerful customer.

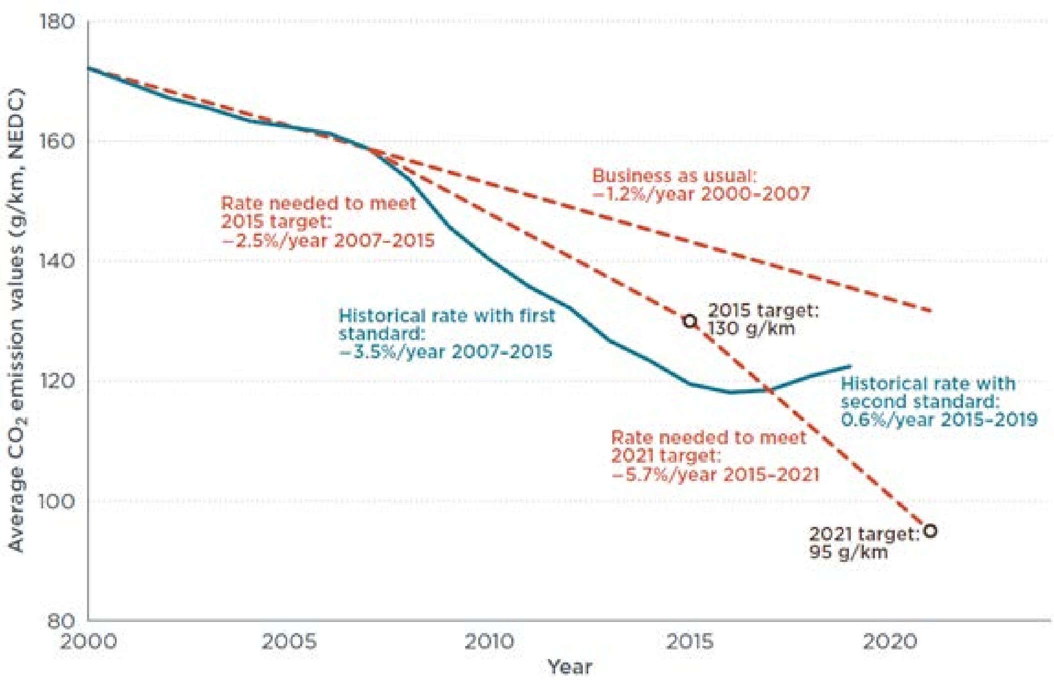
50. Sivaram V., Bowen M., Kaufman N. & Rand D. 2021. "To Bring Emissions-Slashing Technologies to Market, the United States Needs Targeted Demand-Pull Innovation Policies", Columbia Center on Global Energy Policy.
51. Taylor M. R., Rubin E. S. & Hounshell D. A. 2005. "Control of SO2 emissions from power plants: A case of induced technological innovation in the US ", *Technological Forecasting and Social Change*, 72:6, pp. 697-718.
52. For example, the EU already promoted the public procurement of clean vehicle fleets at the national level. The revision of the Clean Vehicles Directive (2009/33/EC) introduced a definition of clean vehicles and sets minimum targets for their public procurement in each member state.

3.2 ▪ Set standards to ease the diffusion of incremental and modular innovations

Non-technology specific regulatory instruments can effectively help diffuse incremental and modular innovations. It is especially important for the automotive sector, where economies of scale are critical for success. In this sector, the regulatory instruments include regulation of tailpipes emissions (nitrogen oxide, sulphur oxide, CO2 and particles), and legislation forcing fuel suppliers to blend a share of renewable fuel into gasoline. In the early 1990s, the EU introduced a comprehensive framework to significantly reduce noxious emissions from diesel engines[53], followed by gradually tightened standards from 1996 up to 2020[54]. It resulted in a 90% reduction of noxious pollutants in new EU registered vehicles.

EU cap on CO2 emissions from new vehicles has been driving positive development of existing energy efficient technologies, but recently improvements were counterbalanced by the development of heavier cars. In 2008, the EU adopted a regulation to cap the carbon dioxide emissions of new vehicles. The first step amounts to an average of 130 g CO2/km and has been legally implemented in 2012-15 and the following step (95 g CO2/km) was implemented in 2020. This regulation has been driving the development, improvement and diffusion of a number of existing technologies, such as turbo charging, start/stop systems and more advanced valve management systems. This has also led companies to include technologies for the electrification of their fleet. However, despite those positive developments, car manufacturers also developed Sport Utility Vehicles (SUVs) that are heavier and more polluting. This choice led to a slow-down in energy efficiency improvements and a recent increase of the average carbon dioxide emissions of new cars in Europe (Figure 7).

FIGURE 7 ▪ Historical average CO2 emission values, targets, and annual reduction rates of new passenger cars



Source: ICCT Briefing, CO2 emissions from new passenger cars in Europe, August 2020

53. Starting with the Euro 1 level (1992).
54. Through Euro 2 (1996), Euro 3 (2000), Euro 4 (2005) and Euro 5 (2009).

3.3 ■ Ensure that technology specific infrastructures are available to ease the roll-out of network-based innovations

EU policy makers have a role to play especially in situations where network effects or technology lock-in impact the diffusion of innovation.

Prior investments in dirty energy technologies and path dependency may make it difficult to transition to clean technologies. Technology lock-in established technologies happens due to high costs of switching to another technology. **Network externalities can increase the cost of changing technology**[55], when the benefits of using a given technology depend on its diffusion. Technology-specific infrastructure makes a given technology more economical, but emerges only as the technology is widely used. Some green technologies depend on an underlying infrastructure and compete with fossil-based technologies for which such infrastructure is already in place. For example, the vast network of oil refuelling stations and the yet limited network for electricity/hydrogen refuelling stations is a key element in a buyer's choice between a petrol and an electric/hydrogen vehicle (such as an electric passenger car, and a hydrogen truck). To promote the development of electric vehicles, charging stations must be in place. However, the private sector has little incentive to provide charging stations without existing demand from electric vehicles.

In such a 'chicken and egg' problem, clear technology standards provide guidance to firms as to the expected future direction of technology[56]. Government adoption of electric vehicles may be an effective instrument for supporting diffusion of charging stations and mitigating the problem of network externalities[57]. For private infrastructure, the amended Energy Performance of Buildings Directive (EPBD) requires that member states adopt rules for the installation of a minimum number of EV charging points in some residential and non-residential buildings. The EPBD also provides rules for the spread of private smart charging infrastructure for EVs and for vehicle-to-building or vehicle-to-grid services (90% of charging events take place in private areas). This directive includes provisions to simplify the deployment of charging points by addressing regulatory barriers, including permitting procedures. For public facilities, the EU directive on deployment of alternative fuels infrastructure (AFID) sets out a common framework for the installation of public infrastructure, including the standardisation of requirements for the supply of electricity, natural gas and hydrogen in road and waterborne transport.

3.4 ■ Combine ecodesign regulation with energy labelling to contribute to the large diffusion of innovations

Eco-design and energy labelling are designed to work together in a "push and pull" dynamic (*cf*. integrated model presented in Box 2).

Eco-design consists in integrating environmental aspects into the product development process, by balancing ecological and economic requirements. Setting minimum requirements for energy efficiency promotes product innovation and "pushes" the market away from the

55. Lehmann P. & Söderholm P. 2018. "Can Technology-Specific Deployment Policies Be Cost-Effective? The Case of Renewable Support Schemes." *Environmental and Resource Economics*, 71:2, pp. 475–505.
56. Vollebergh H., van der Werf E. 2014. "The Role of Standards in Eco-innovation: Lessons for Policymakers", *Review of Environmental Economics and Policy*, 8: 2 Summer, pp. 230-248.
57. Corts K. 2010. "Building out alternative fuel retail infrastructure: Government fleet spillovers in E85", *Journal of Environmental Economics and Management*, 59, pp. 219–234.

worst-performing products. This includes embedded emissions (*e.g.* the use of wood instead of steel concrete in buildings), energy consumption (*e.g.* energy performance of appliances), as well as recycling (*e.g.* new legislation on batteries).

Compulsory information and communication measures, such as eco-labelling, can reinforce the efficiency of the ecodesign regulation and contribute to innovation's large diffusion. First, by encouraging consumers to make better-informed decisions about their purchase, like in the case of paper products[58], energy labels "pull" the market towards greater energy efficiency. For example, energy efficiency labelling has proved effective in pulling emerging technologies into the market[59]. Second, by providing consumers with information about the environmental performance of products, eco-labelling can also give incentives for industry to develop more efficient products and innovations beyond the minimum eco-design levels.

The EU has strong eco-design, labelling and minimum energy efficiency standards, covering 27 energy-related product groups placed on the EU market, regardless of their origin. They helped to keep in check energy demand growth from new appliances, notably for space cooling. Regarding electricity demand, the Eco-design Directive has led to the progressive phase-out of inefficient incandescent light bulbs, leading the way to more efficient LEDs. Energy efficiency of boilers has been regulated since 1992: eco-design and energy labelling requirements for space and water heaters were enacted in 2013, banning the sales of the least efficient boilers.

3.5 ■ Oust polluting technology when clean solutions are available to promote the large-scale deployment of clean energy

Bans and phase-outs of inefficient or polluting technologies can open space for innovative solutions. Such "discontinuation" policies are particularly relevant to speed up the diffusion of clean innovation. Phase-out policies are being implemented in the energy sector (coal exits in Germany, the UK, Spain, Slovakia, Quebec and many other countries in Europe and the rest of the world) and in the transport sector (*e.g.* with Norway proposing to phase out petrol and diesel cars by 2025). By creating space in future markets, discontinuation policies act as transformative demand-pull instruments that accelerate clean energy innovation deployment.

In the energy efficiency sector, the EU has adopted two legislative acts to control emissions from fluorinated greenhouse gases (F-gases), including hydrofluorocarbons (HFCs). The F-gas regulation bans the use of F-gases in many new types of equipment where less harmful alternatives are widely available, such as fridges in homes or supermarkets, air conditioning and foams and aerosols. It also limits the total amount of the most important F-gases that can be sold in the EU from 2015 onwards and phasing them down in steps to one-fifth of 2014 sales in 2030. The MAC Directive prohibits the use of F-gases with a global warming potential of more than 150 times greater than carbon dioxide (CO2) in new types of cars and vans introduced from 2011, and in all new cars and vans produced from 2017.

58. Popp D., Hafner T. & Johnstone N. 2011. "Environmental Policy vs. Public Pressure: Innovation and Diffusion of Alternative Bleaching Technologies in the Pulp Industry", *Research Policy*. 40(9), pp. 1253-1268.
59. Costantini V., Crespi F. & Palma A. 2017 "Characterizing the Policy Mix and its Impact on Eco-innovation: A Patent Analysis of Energy-Efficient technologies" *Research Policy*, 46, pp. 799-819.

4 ▪ RECOMMENDATIONS TO ADOPT EU REGULATIONS THAT BOOST CLEAN ENERGY INNOVATION

4.1 ▪ Build a political narrative on the 'Fit for 55' as being also 'Fit for innovation' and 'Fit for climate neutrality'

As exemplified by the nickname "Fit for 55 package", the core narrative around this legislative proposal can be summarised as "we want a climate target of at least 55% by 2030, we should adapt the legislation to deliver this objective". Such a technical narrative has its merits but also its limits (see Box. 4). Yet, in our view, the European Commission should complement it with two narratives:

- **A 'fit for climate neutrality' narrative, centred on 'climate neutrality by 2050'.** This should support the European Commission in presenting clear objectives, targets and regulations that are vital to develop today the clean solutions that will be necessary to deploy in the 2030s and 2040s to reach climate neutrality. It should also be more politically consensual as the 2050 EU-level objective has already been supported by all 27 Heads of States and Governments of the EU[60], Poland included, and by an overwhelming majority of Members of the European Parliament. Until recently, the 55% objective appeared more controversial, but the Parliement asking for an even more ambitious objective of 60% may help to make it more acceptable[61].
- **A 'fit for innovation' narrative, that could also be framed as a 'fit for clean technology'** narrative. Such a narrative can build on the economic and innovation opportunities offered by the climate transition. As 75% of the global economy now aims at carbon neutrality[62], China and the US are investing heavily to become the global leaders of the green economy. Their successes in achieving dominance in digital technologies suggest that China and the US will do whatever it takes to give their businesses the best head-start. In this context, the European Union currently holds a technological and competitive edge in many sectors, not least because it has already implemented forward-looking regulations that the US lacks[63] –for instance a CO2 standard for cars. The European Commission should therefore ensure that its FitFor55 proposal includes measures that create new markets for clean solutions that already exist, as well as for clean solutions that are being created. Such 'demand shock'[64] for clean and innovative solutions will give market certainty to thousands of European innovators and investors, so they can test, pilot, demonstrate, scale up and industrialise green solutions in Europe in the 2020s, and conquer foreign markets as China, the US, Japan and others translate their climate neutrality pledges in concrete policy measures.

60. European Council, European Council Conclusions, 11 December 2020.
61. European Parliament. 2020. "EU climate law: MEPs want to increase 2030 emissions reduction target to 60%", press release, 8 October.
62. Delair M., Magdalinski E. & Pellerin-Carlin T. 2020. "5 years after the paris agreement, the largest global economies are engaging in the race towards climate neutrality", infographics, 9 December.
63. Knudsen E. & Pellerin-Carlin T. 2020. "Making transatlantic relations green: a common agenda for climate action", policy brief, 3 December.
64. www.cleantechforeurope.com

BOX 4 ▪ Beyond 2030, the FitFor55 Package is especially important to reach climate neutrality by 2050.

The European Commission presents the 'Fit For 55 Package' as a tool specifically designed to reach its proposed 2030 climate target. This raises two concerns as (1) proposing new EU regulations in 2021 is slightly late to have a massive impact as soon as 2030; (2) delivering climate neutrality by 2050 will remain within reach only if the European Commission proposes ambitious regulations in the year 2021, especially for sectors where climate-neutral solutions currently do not exist at scale.

(1) Proposing changes to EU regulations has a limited impact on greenhouse gas emissions in the short term. It usually takes 18-24 months for the European Union's democratic decision-making process to reach an agreement. With hard work, the Fit For 55 Package proposals to be outlined in June and December 2021 may lead to a final agreement by the European Parliament and Council in 2023. As always, specific elements of those legislations will enter into force gradually, to provide public authorities, investors and businesses as much regulatory visibility as possible. When looking at previously adopted regulations, note that the Energy Performance of Buildings Directive (EPBD) was proposed in November 2016, adopted in December 2018, and gave Member States around 1,5 years (i.e. until 10 March 2020) to adopt the legislation necessary to comply with this directive.[65] One should moreover account for the frequent delays of national administration, with most governments for instance missing the EPBD deadline by more than six months, and eight Member States still having failed to submit a long-term renovation strategy in February 2021, almost a year after the deadline.[66] All in all, as a rule of thumb, **one can expect that many of the Fit for 55 package's decisions will be fully implemented after 2026**. And as it takes anything between 1 and 15 years for energy, transport or industrial projects to develop, and as most of the 2030 energy assets have already been built (*cf.* figure 6), it is likely that most of the impact of the Fit For 55 Package decisions will be felt after 2030 rather than before.

Conversely, reaching climate neutrality by 2050 will remain within reach only if the right policy and investment decisions are taken in the 2020s:

- First, the very long lifetime of buildings, energy, transport and industrial assets (*cf.* figure 6) that virtually guarantee that all the urban infrastructure, new buildings, industrial and power plants built in the 2020s will still be used in 2050. This will also be the case of most cars or heating systems built in the 2030s.
- Second, it takes time to bring clean innovations from laboratories to markets. This time can be limited to a few years in some limited areas such as digital apps to better manage one's energy consumption, or take one or several decades for the most deep technological innovations, such as the current futuristic plan of Airbus to create a hydrogen-powered aircraft by 2035.

Therefore, **2050 greenhouse gas emissions are already partially determined by the investments made, and the investments not made in the 2020s**.

To fully embrace the opportunities of the transition to climate-neutrality, businesses and public authorities need to move from forecasting to backcasting. Forecasting essentially aims to look at what the future may entail, while backcasting starts with defining a desirable future (in our case, climate neutrality by 2050) and then identify the concrete milestones and policies that can connect today's situation with that particular desirable future. This is why this policy-paper argues that the European Commission should also approach its 'Fit For 55 package' as a backcasting exercise to put the European Union on a path for climate neutrality by 2050.

For instance, to be prosperous and climate-neutral in 2050, Europe needs domestic green steel production. This requires the phase-out of all coal-powered steel factories by 2049 at the latest, and the phase-in of green steel factories that will use different technologies and processes and produce close-to-zero greenhouse gas emissions. Such massive phase-in will not happen in a single year, it will be gradual and should therefore start in the 2030s. For such massive deployment to occur, businesses should already have tested green steel processes and technologies, in laboratories, with early prototypes, large prototypes, pre-commercial demonstrators, commercial demonstrators etc. already in the 2020s, and thus need financial and regulatory signals to reduce the market risks associated with such breakthrough innovations.

65. European Union. 2018. *Energy Performance of Buildings Directive*, 30 May.
66. European Commission. 2021. *Preliminary analysis of the long-term renovation strategies of 13 Member States*, 25 March.

4.2 ■ Guiding principles for a FitFor55 that stimulates climate-neutral innovation

Concretely, the EU can activate different regulatory policy instruments to foster the development of future innovation and accelerate the diffusion of mature innovation.

Uncertainty is a major factor inhibiting breakthrough and systemic clean energy innovations. This is true particularly at the early stage of the innovation process: more immature technologies present a greater risk for investors, as developing new technologies usually involves high up-front investments with long pay-back periods. Stringent long term environmental targets, flexibility and extended compliance periods are crucial to reduce those risks and spur an innovation-push. The European Commission should design its forthcoming EU regulatory proposals on the basis of these three essential criteria to create a secure environment in a long term perspective that helps pull the private resources into clean energy research and innovation:

- **Set clear, ambitious and binding objectives for specific sectors.** This should help divert investment away from polluting technologies and direct innovation towards clean energy solutions. A stable regulation policy based on stringent standards is vital to foster the creation and deployment of breakthrough innovations.
- **Give companies and innovators flexibility to find the best solution to comply with ambitious targets.** Performance standards, that allow flexibility as to how the performance targets are met, should thus be favoured over technology-based standards that specify the method or equipment that firms must use to comply with a particular regulation.
- **Give companies and innovators time to adapt and experiment different solutions.** This is especially relevant in sectors that require initiating breakthrough innovation and thus need a long period of research and development, before providing technologies ready for commercialisation. Stringent objectives should be combined with a flexible time strategy to reflect the state of technological developments in an accurate and timely manner. In addition, allowing compliance periods will make an ambitious policy more acceptable.

To accelerate the spreading of technologies that have reached the commercialisation stage, regulatory policies can create a demand shock by sustaining demand through market creation:

- At the demonstration phase (TRL 7-TRL 8), demand-pull innovation policies can focus narrowly on **creating and shaping early markets for emerging technologies** with measures that are targeted at mediating the transition of technologies from R&D to commercial scale-up, and create niche markets to begin scaling up emerging technologies with higher risk profiles and costs. **The European Commission should, for instance, create a niche market for green steel** by mandating Green Public Procurement upper limits for carbon intensity of steel used for public buildings.
- When the technology has reached the adoption phase (TRL 9-TRL 10), demand-pull policies can **support the large-scale deployment of clean energy**, by enacting clean energy standards that encourage private investors and firms to scale up and commercialise new technologies. **The EU regulation on CO2 standards for cars could for instance include an ambitious objective of zero emission** by a specific date (*e.g.* 2025-2030 for two-wheelers, 2030-2035 for passenger cars).
- Demand-pull policies also have a key role to play for the **large scale diffusion of network-innovation based technologies**. In this case, compatibility and interface standards are crucial to ensure the users that a compatible network is available. This is

especially important for the shift to clean mobility. **The European Commission should therefore revise the Directive on deployment of alternative fuels infrastructure (AFID)** in a way that ensures that Member States guarantee the adequate deployment of charging infrastructure, especially electricity and hydrogen charging points.

- **Informing consumers about the environmental performance of products** through ecolabelling contributes to pull emerging technologies into the market. The European Commission could for instance include a **requirement for EU standard Environmental Product Declarations for all components in the construction process of new buildings and new cars, as well as a labelling system** to educate the public and create demand-pull for green cement and green steel.
- Finally, **ousting polluting technologies when clean alternatives are available**, in order to drive the large-scale deployment of mature green solutions (TRL 11). The European Commission should therefore set a European near-zero CO2 emission threshold for new buildings in the Energy Performance in Buildings Directive, to exclude the use of inefficient technologies (*e.g.* gas-fired boilers), and contribute to the spread of high efficiency technologies (*e.g.* heat pumps).

CONCLUSION
THE 'FIT FOR 55 PACKAGE' SHOULD ALSO BE 'FIT FOR INNOVATION' TO DELIVER CLIMATE NEUTRALITY BY 2050

As major economies like the EU, the US and Japan now aim to reach climate neutrality by 2050, cleaner energy innovations need to be developed, and deployed faster and at a greater scale.

Next June, the European Commission is set to present its 'Fit for 55 package' that should help the European Union deliver on its expected objective to reduce EU greenhouse gas emissions by at least 55% by 2030. Our paper however notes that **decisions that can deliver quick environmental results by 2030, may not be sufficient to promote the breakthrough innovations necessary to achieve climate neutrality by 2050.**

Some measures that allow the reduction of pollutants in the short term by encouraging the uptake of incremental improvements may discourage breakthrough and systemic innovations by leaving insufficient time to develop long-term, innovative solutions.

Regulation policies offer a range of policy tools to tackle barriers to innovation all along the innovation process. The main challenge for the EU is to **identify instruments adapted to both the maturity of the innovations and the needs of the different sectors, and to mobilize them in a relevant timeframe**.

Many promising technologies are still at early stages of development (TRL 4 to TRL 8). This is particularly true in the industry and the long distance transport sectors, whose decarbonisation is vital to achieve climate neutrality by 2050. Alongside innovation-push policies such as public funding for clean energy innovation, **EU regulations can help pull the private**

resources into R&D by providing clear signals that there will be new green markets after 2025 (e.g. through public procurement) and throughout the 2030s (e.g. through forward looking, predictable, and stringent regulatory changes).

Emerging and mature innovations (TRL 9 to TRL 11) in passenger vehicles (*e.g.* battery electric cars) and the building sector (*e.g.* deep renovation of residential buildings) offer opportunities to meet medium-term targets in a way that is consistent with the long-term objective of climate neutrality by 2050. In these sectors, **EU regulatory policies can create a demand shock by shaping early markets for emerging technologies and supporting mass deployment of mature clean energy technologies.** ■

L'Europe pour les citoyens

PREMIER MINISTRE

Institut Jacques Delors
Penser l'Europe • Thinking Europe • Europa Denken
18 rue de Londres 75009 Paris, France • www.delorsinstitute.eu
T +33 (0)1 44 58 97 97 • info@delorsinstitute.eu