2. Innovating to drive an energy transition for all Europeans

by Thomas Pellerin-Carlin

The energy transition is introducing new technologies, processes, services, techniques and behaviours in human organisations; it is a process of innovation on a massive scale.

Research and innovation (R&I) are key enablers for a swifter, cheaper and fairer energy transition. Well-crafted energy R&I policies and actions, supported by an appropriate market design and enabling policies, can moreover foster a renewed European approach to competitiveness, industrial policy and citizen involvement in 21st century Europe.

This chapter[101] looks at R&I in the context of the energy transition[102]. It begins by highlighting the critical role of R&I, not only as the 5th dimension of the Energy Union, but as an enabling area where public support is critical to reap the benefits of the energy transition. It then provides an analysis of the current strengths of Europe in the global clean energy race, notably its academia and businesses. It describes the many relevant EU policy tools and highlights areas that need to be improved. Finally, it provides policy recommendations to foster an adequate transformation of EU energy policy as well as the renaissance of energy incumbents into the energy transition tigers Europe needs them to become.

101. The author would like to thank Pierre Serkine and Julia Reinaud for their key contribution to this chapter.
Several sections of this chapter build on previous publications of the Jacques Delors Institute, in particular: Thomas Pellerin-Carlin and Pierre Serkine, "From Distraction to Action – towards a bold Energy Union Innovation Strategy", Policy Paper No. 167, Jacques Delors Institute, June 2016 ; Thomas Pellerin-Carlin and Pierre Serkine, "Europe needs crowd-based innovation for a competitive energy transition", Tribune, Jacques Delors Institute, September 2016.
102. For a definition of the energy transition, see the introduction.

2.1. Public sector support is key to drive a swift and competitive energy transition

In its February 2015 communication, the European Commission highlighted five dimensions of the Energy Union. Its fifth dimension is "research, innovation and competitiveness" (see box 1 for the definition of those three notions).

The European energy transition has already started and disrupted traditional energy sector business models (2.1.1.), driven by new policies, technologies but also enabled by digitalisation—among other megatrends shaping the energy system[103]. Businesses thus need to become the leaders in the booming global markets of renewables and energy efficiency (2.1.2.), to make Europe a leader driving a global energy transition (2.1.3.). To do that, private sector initiatives must be complemented by (and work closely and collaboratively with) the public sector. Public R&I support is critical for the energy revolution, much like it has been for the digital revolution (2.1.4.).

BOX 1 ► Defining research, innovation and competitiveness[104]

Research is the process of *creating* ideas, processes, technologies, services or techniques that are *new to the world*. In terms of input, available statistics often refer to Research & Development (R&D) spending.
Innovation is here defined as introducing something *new to a given organisation*—but not necessarily *new to the world*. For innovation to be beneficial, it must be useful and valuable, and can often be monetised.
Competitiveness is a too-often ill-defined[105] buzzword excessively used as a synonym for cost-competitiveness[106] (i.e. cost-minimisation: "doing what everyone does, but cheaper"), a definition that Paul Krugman assesses to be "not only wrong but dangerous"[107]. A more holistic approach to competitiveness is useful to embrace what makes competitiveness for the European economy in 21st century globalisation: the capacity to "do what no one else can do[108]", something that is first and foremost characterized by one's capacity to innovate[109].

103. See Annex 1
104. Those definitions synthesis the more complete definitions given in Thomas Pellerin-Carlin and Pierre Serkine, "From Distraction to Action – towards a bold Energy Union Innovation Strategy", Policy Paper No. 167, Jacques Delors Institute, June 2016.
105. The concept of "competitiveness" is criticised by academics. For instance, Robert Reich considers competitiveness as one of those "few terms in public discourse [to] have gone so directly from obscurity to meaninglessness without any intervening period of coherence". Robert Reich, *American Competitiveness and the President's new relationship with American Business*, 21 January 2011. For a deeper critical discussion on the definitions of competitiveness, see Karl Aiginger, Susanne Bärenthaler-Sieber, Johanna Vogel, "Competitiveness of EU versus USA", WWWforEurope Policy Paper, No.29, November 2015.
106. European Commission, *Energy Union Framework Strategy*, 25 February 2015, p. 10
107. Paul Krugman, *Competitiveness: A dangerous Obsession*, Foreign Affairs, March/April 1994
108. Andrea Ovans, *What is Strategy Again?*, Harvard Business Review, May 2015
109. Other definitions exist, among which the World Economic Forum defines "competitiveness as the set of institutions, policies

2.1.1. Businesses must innovate to survive the energy transition

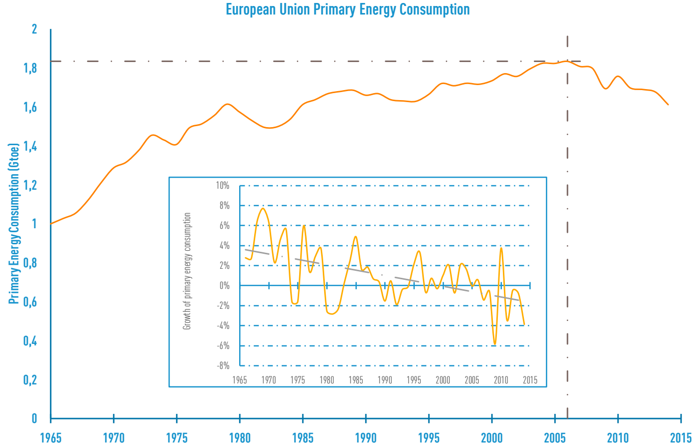
"We have to move away from an economy driven by fossil fuels, an economy where energy is based on a centralised, supply-side approach and which relies on old technologies and outdated business models."
European Commission, Energy Union Framework Strategy, 25 February 2015

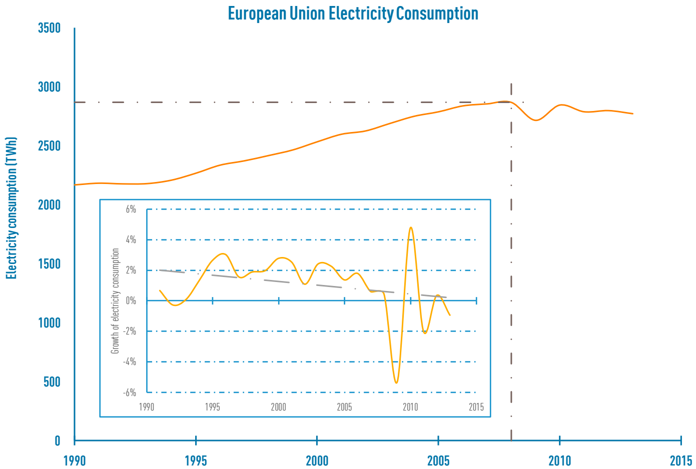
The traditional business model of energy incumbents was based on selling the greatest amount of energy at the highest possible price. This is no longer possible with the decline of EU energy consumption that started in 2006, and the decline in EU electricity consumption that started in 2008[110] (see figure 1). As the European Commission rightly argued in its 2015 Energy Union Strategy, "we have to move away from … [those] outdated business models". The question is now straightforward: which companies will successfully change to reap the benefits of the energy transition? How can policy makers help companies transition ?

and factors that determine the level of productivity of an economy", hence using competitiveness as a synonym for "elements improving productivity". See Klaus Schwab, *The global competitiveness report 2015-2016*, World Economic Forum, 2015.

110. Some services of the European Commission however seem to assume that electricity demand will increase in the future. A possibility still not backed by certainty. While electrification of transport and heating indeed pushes electricity consumption upwards, energy efficiency pushes electricity consumption downwards, and it is unclear how speedy and important both elements will be. See European Commission Impact assessment, COM(2016) 861 final: p.24: "Moreover, electricity demand will progressively reflect the increasing electrification of transport and heating. "; p.39: Table indicating increase from 3090 TWh in 2015 to 3397 TWh in 2030

FIGURE 1 ► Evolution of EU Primary Energy Consumption and of its growth rate between 1965 and 2014 (top) and evolution of EU Electricity Consumption and of its growth rate between 1990 and 2013 (bottom)





Source: T. Pellerin-Carlin and P. Serkine, Jacques Delors Institute, data from *BP Statistical Review 2015* (graph on the left) and from *Eurostat* (graph on the right)

It is still time for European energy companies to shift, and some already started their own transition. German energy company E.ON. for instance created two distinct entities to keep its "forward looking" activities related to networks, renewables and customer solutions in the entity E.ON., while putting "traditional" activities (coal power generation, energy trading, and exploration and production) within a new entity named Uniper. Similarly, GDF-Suez radically changed its organisational layout, with a name-switch to Engie and the restructuration of its activities.[111] Beyond E.ON. and Engie, companies like Centrica, ENEL, and EDP have also taken significant steps to try to build a business model that can work in the energy transition.

Other companies (e.g. EDF, RWE) are testing new business models via their subsidiaries, but their board remain split and have taken too few ambitious and forward-looking decisions.

Policy makers have an important role to play in stimulating incumbents to become the energy transition tigers Europe needs. This choice for the transformation—rather than extinction—of incumbents is driven by three main reasons:

- Incumbents already have the manpower, financial capacity and customer relationship to foster mass-scale engagement in the energy transition through more massive adoption of innovations. They can thus be efficient tools to foster the energy transition in Europe and allow Europeans to lead the global clean energy race (see 2.1.2.).
- Many incumbents, such as RWE or EDF, are largely owned by public entities. Their shutdown would thus become a massive burden on public debts, at a time when the Eurozone is not prepared enough to face the next economic crisis[112].
- Incumbents failures would lead to the loss of hundreds of thousands of quality jobs. Besides the impact a job loss may have on one's personal and

111. "Faced with an evolving energy market, this transformation is intended to serve the development of our group and our position as the global leader of the energy transition. It will allow us to take on the many challenges of the energy market: decarbonisation of the energy mix, digitalisation of activities, decentralisation of energy production and development of energy efficiency." Gérard Mestrallet, then CEO of Engie, 4 January 2016. In a more concrete way, while Engie keeps its two traditional lines of work: gas chain, and centralised production of electricity, it completes it wish three lines of works that are consumer-centric: B2T (i.e. providing solutions for "territories" understood as cities and other local entities), B2B (i.e. providing solution to businesses), and B2C (i.e. providing solution to residential consumers).
112. Henrik Enderlein, Enrico Letta et al. (2016). *Repair and Prepare: Growth and the Euro after Brexit*, Gütersloh, Berlin, Paris: Bertelsmann Stiftung, Jacques Delors Institut – Berlin and Jacques Delors Institute in Paris

family life, many may be too old to find another job, others may need to be retrained through publically funded vocational training. This human and economic costs for individuals and society can be avoided if incumbents transform themselves: the transition for a worker would be smoother as he/she can stay within the same company, without losing his/her job nor sense of belonging to a specific working group, while potential vocational training could be done in house, thus at a much lesser cost for public budgets. In other words, a transition based on the transformation of incumbents is likely to be a fairer transition for European workers.

Innovation, including business model innovation, is therefore a key element to mitigate the negative impacts of the energy transition. It is an element of the Social Pact for the energy transition that this report advocates in chapter 4.

2.1.2. Europe should become the global provider of clean energy solutions to boost its economy

*"We need to strengthen the share of renewable energies on our continent.
This is not only a matter of a responsible climate change policy.
It is, at the same time, an industrial policy imperative
if we still want to have affordable energy at our disposal in the medium term.
I strongly believe in the potential of green growth.
I therefore want Europe's Energy Union to become
the world number one in renewable energies. I would also like
to significantly enhance energy efficiency beyond the 2020 objective."*
Jean-Claude Juncker, Strasbourg, 15 July 2014.

The energy transition rests on two main pillars: renewables and energy efficiency[113]. Those two elements are booming global markets.

The figure below from the International Energy Agency (IEA) highlights three scenarios:

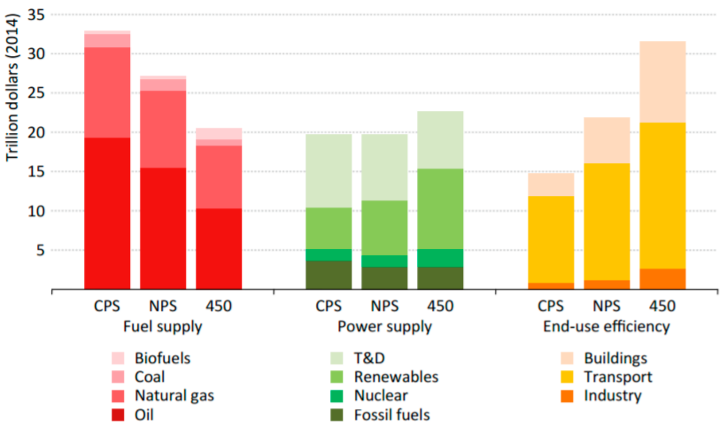
- "CPS" is a business as usual scenario.

113. There are other dimensions to the energy transition, such as ensuring flexible supply and demand of electricity, energy storage, and systems integration.

- "NPS" is a scenario where policy makers barely implement the decisions they announced before the Paris Agreement. In this scenario, investments in fossil fuels are smaller than investments in renewables and efficiency combined (see scenario "NPS" in figure 2).

- In the "450" scenario where decisions would be taken to limit the increase in the global average temperature to 2°C above pre-industrial levels, renewables and efficiency investments combined would represent around 35 trillion USD over the 2015-2040 period, compared to 25 for fossil fuels. In this scenario, the yearly investment in renewables and energy efficiency represents an amount similar to the GDP of a country like Russia[114].

FIGURE 2 ► Cumulative world energy sector investment by sector and scenario, 2015-2040



Note: CPS = Current Policies Scenario; NPS = New Policies Scenario; 450 = 450 Scenario; T&D = transmission and distribution.

Source: International Energy Agency, World Energy Outlook 2015, p. 60

114. This calculation is not meant to be entirely precise but to provide the reader with a general order of magnitude of the renewables and energy efficiency markets in the world. This comparaison is based on the IEA estimated in both NPS and 450 scenarios, divided by 25 as if those investments would be equally spread over the 25 years of the IEA 2015-2040 scenario. This gives an average number similar to Russia's 2015 GDP that, according to World Bank Data, is estimated at a level of 1.331 billion dollars.

Well-crafted energy R&I policy and actions are crucial to help European companies to be well positioned on those booming markets (see 2.1.4.). This would increase Europe's prosperity and would also:

- Create quality jobs. As European businesses' competitiveness will be based on innovation, it is more likely to ensure that it leads to the creation of well-paid quality jobs for European workers (see chapter 4.).

- Diversify our export sectors to protect Europeans from violent external economic shocks. This is of particular importance for countries whose exports heavily rely on few economic sectors. To illustrate, if China were to become a potent car exporter like it became a potent exporter of other goods, the German economy would be "under massive [economic] pressure"[115]. It is thus important for EU and national economies to ensure Europe's capacity to diversify its exports to increase the protection of European workers and taxpayers from external economic shocks.

- Ensure that Europeans act concretely to make the European energy transition a global energy transition (see 2.1.3.).

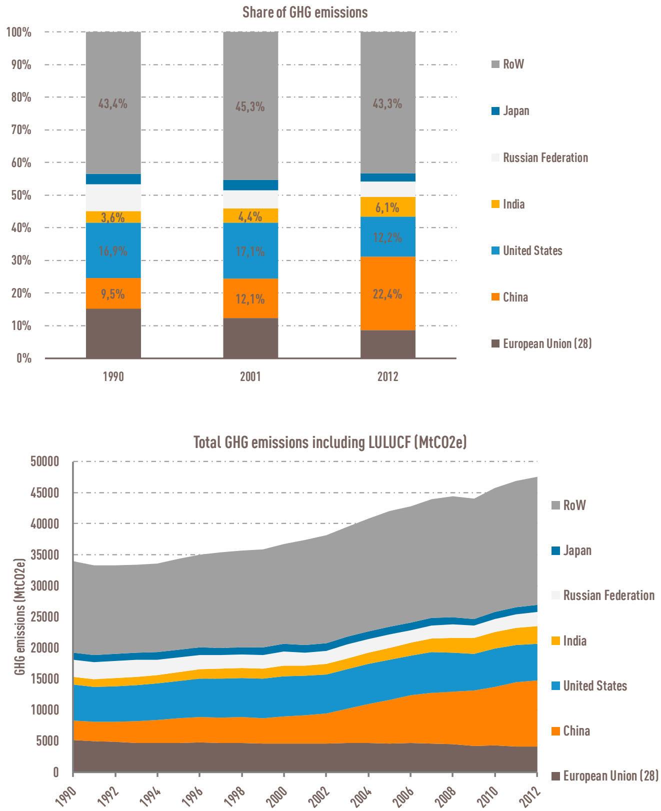
2.1.3. Research and innovation is Europe's best tool to trigger a global energy transition to fight climate change

"We have the [Paris Climate] deal. Now we need to make it real."
European Commissioner for Climate Action Miguel Arias Cañete [116]

Current EU and national policies tend to focus on the greenhouse gas emissions happening on their territory. Yet, climate change is fed by global greenhouse gas emissions, of which the EU represents only 8.7%[117]. This share is moreover steadily declining as EU emissions decline while others' increase (see figure 3).

115. Georg Zachmann, "An approach to identify the sources of low-carbon growth for Europe", Bruegel, 2016.
116. Miguel Arias Cañete, Speech in Brussels, 02 March 2016.
117. CAIT Climate Data Explorer. 2015. Washington, DC: World Resources Institute. Available online.

FIGURE 3 ► Share of total GHG emissions in 1990, 2001 and 2012 (top), and corresponding evolution of GHG emissions from 1990 to 2012 (bottom)



Source: T. Pellerin-Carlin and P. Serkine, Jacques Delors Institute, data from the World Resources Institute

By contrast, the EU is the world's biggest economy with 23.7% of global GDP[118]. Europe should further use its economic and innovative strengths to impact 100% of global emissions—rather than the EU's 8,7%. In this regard, energy R&I is of critical

118. Data from the World Bank

importance as many EU innovations can be exported or be inspirations for innovations in the rest of the world. Using its R&I, trade and development aid tools, the EU should aim at co-developing the goods and services helping developing countries to **leapfrog**: i.e. to go from poverty to low-carbon prosperity, without going through a phase of high-carbon economic development. Leapfrogging already occurred in other economics sectors, such as in telecommunications as poor countries went from no-phones to masse-scale diffusion of mobile phones—without going through a landline phone phase. In this endeavour, Europe's biggest challenge is fostering access to (renewable) electricity for all Africans (see chapter 1., section 1.3.).

2.1.4. Public support for research and innovation fosters private sector competitiveness

"In terms of policies, this cartoon image has fed into very concrete ways in which we think about innovation. Basically we see this roaring lion in a cage, business, with different types of impediments which prevent it from innovating. Government's role is to take away these impediments through R&D tax credits, getting rid of red tape and through different ways of incentivising innovation. If we look at many of the current innovation policies, they are actually driven by this image, which . . . is the wrong one because what we often have in the private sector is the nonwillingness to roar. Keynes outlined this idea to Roosevelt in 1936, he stated that we actually do not have these lions and wolves and tigers in the business community, we have a bunch of domesticated animals—gerbils, hamsters and pussycats. The role of policy therefore is to make them grow up and want to be lions."[119]
Marianna Mazzucato, 2014

Marianna Mazzucato highlights the misleading representation of innovation as stemming only from a business community made of roaring lions. In this narrative, the public sector resembles a clumsy elephant unable to "pick the winners"[120] and that should be limited to "technology-neutral"[121] and market-

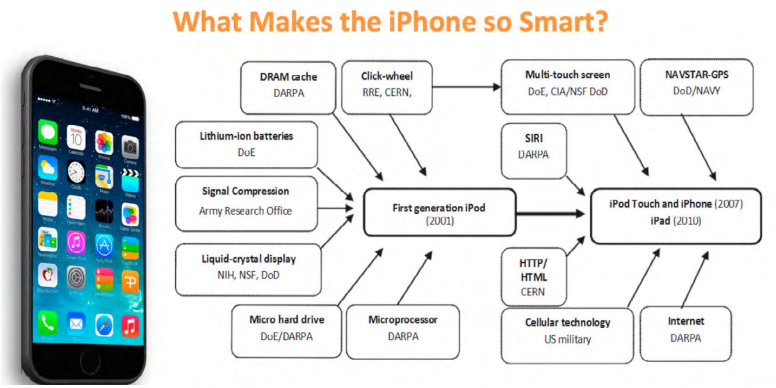
119. Marianna Mazzucato, Speech at the OECD, 28 May 2014
120. For instance, according to then European Commissioner for Competition Policy Neelie Kroes: "Let's be under no illusion: it is markets and not politicians that pick the winners". Neelie Kroes, Speech to the Villa d'Este Forum, 2 September 2006.
121. European Commission, *Energy Union Framework Strategy*, 25 February 2015, p. 14.

based approaches that are only legitimate when addressing "market failures"[122] for instance by creating a CO_2 emissions market such as the EU-ETS[123].

This still dominant narrative is wrong[124]. The reality indeed sees the public sector at the forefront of technological revolutions[125], such as the digital revolution. In this context, innovation policy is here to transform fearful businesses into the energy transition tigers Europe needs.

Looking at the digital revolution, we see that it stems from public sector research and innovation later diffused thanks to public and private sector innovations. Apple's iPhone is illustrative in this regards as it entirely relies on publically-developed technologies (see figure 4).

FIGURE 4 ► Debunking public vs. private sector myths: the example of the iPhone



Source: Mariana Mazzucato[126]

The digital revolution is not the result of a private sector spontaneous generation. It has been consistently pushed by a mix of public sector initiative, public

122. David Edgerton, *The shock of the old – technology and global history since 1900*, Profile Books, 2008, p. 107.
123. For an example of a paper where the EU-ETS is thought as a means to boost innovation, cf. Georg Zachmann, *Making low-carbon technology support smarter*, Bruegel Policy Brief, 2015.
124. Mariana Mazzucato, *The entrepreneurial state: Debunking public vs. private sector myths*, Anthem Press, 2015.
125. Carlota Perez, "Technological revolutions and techno-economic paradigms", *Cambridge Journal of Economics*, 2009
126. Mariana Mazzucato, *The entrepreneurial state: Debunking public vs. private sector myths*, Anthem Press, 2015. p.116

sector decisions constraining businesses[127], and private initiative. The lesson is thus clear for the energy revolution: the public sector entirely legitimate to intervene to promote energy R&I, and the more efficient public sector support to energy R&I is, the more energy companies will be able to benefit and develop innovations ensuring their viability in the energy transition.

2.2. Europe has the assets to lead the global clean energy race

Section 2.1. underlined the importance of R&I in making the European energy transition swifter, more beneficial for the European economy and enabling the forthcoming global energy transition. Let us now turn to Europe's energy R&I assets. Europe has tremendous capacity to lead the global clean energy race (2.2.1.), as well as several adequate—though not perfect—tools to help European researchers and innovators (2.2.2.) in order to enhance European competitiveness, especially *vis-à-vis* Trump's USA (2.2.3.).

2.2.1. Europe has the academia and businesses ecosystem to lead the global clean energy race

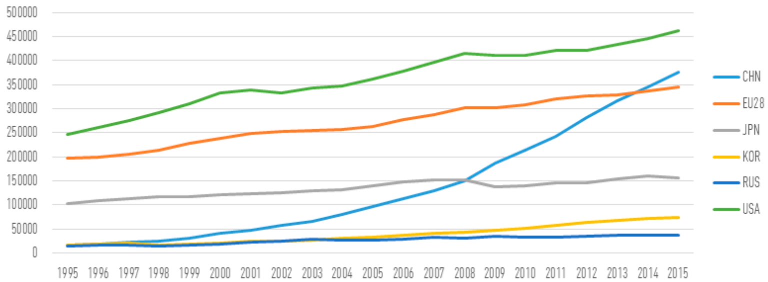
European academia and businesses have been the centre of the first three industrial revolutions. Even though the two world wars destroyed part of Europe's innovative capital and allowed the US to become the epicentre of global R&I, Europe remains a key global player for R&I, especially in the energy sector.

R&D expenditure in Europe is significant (above 2% of EU GDP[128]) and has risen over the past decade (see figures 5 and 6), even if remains below the 3% target endorsed by the Lisbon Strategy. Europe remains, together with the USA and China, in the Top 3 of global R&D expenditure (see figure 5). European businesses also invest a lot in R&D as their investments represent two thirds of EU investment (see figure 6).

127. For instance, the US governement constrained the US private company AT&T to invest important amounts of money in basic and applied research. AT&T thus created the Bell Labs that invented key technologies for the digital revolution (including the transistor) and for the energy transition (with the first use of solar energy to generate a significant level of electricity, in 1954).

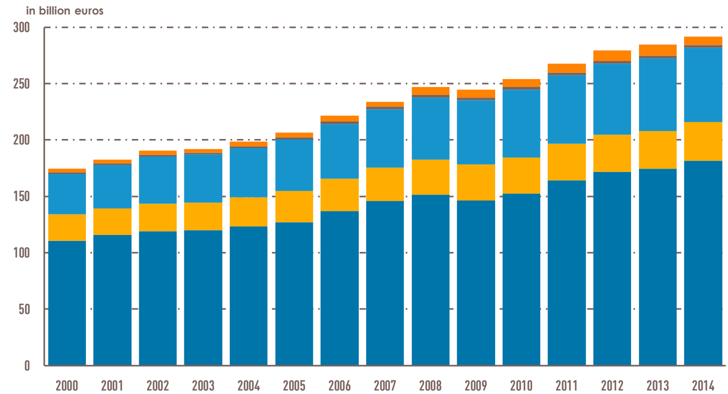
128. Source: OECD data on gross domestic spending on R&D. Several significant Member States have R&D spending significantly below the EU average (2%). This is in particular the case for countries such as Italy (1,3%), Spain (1,2%), Poland (1%), Greece (1%) and Romania (0,5%).

FIGURE 5 ► R&D spending in selected countries (millions of USD)



Source: Jacques Delors Institute, data from the OECD

FIGURE 6 ► Evolution of the R&D spending in the EU by source of funds between 2000 andf 2014[129]



Source: T. Pellerin-Carlin et P. Serkine, Jacques Delors Institute, data from the European Commission and Eurostat

This being said, money invested in R&D is only one input of the R&I process. When looking at proxis for the quality of EU R&I, it appears that EU is amongst the leaders of academic and business R&I, especially in sectors relevant for the energy transition.

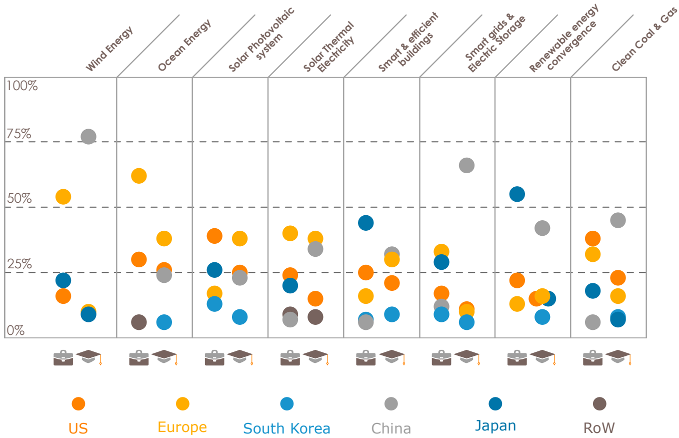
Europe also has an outstanding academic ecosystem for talents to flourish and thrive. To illustrate, according to Reuters, the two most innovative

129. The definitions for the first four sources of funds come from Manual Frascati, *Proposed standard practice for surveys on research and experimental development*, OECD, 2002. "EU (CSF-RI)" corresponds to the sum of H2020 and Euratom.

research institutions in the world are European: the French CEA and German *Fraunhofer*[130] and both are extremely active in the energy sector[131].

The Top 10 report[132] provides a picture of the leading position of Europe academic and industrial players in key energy technologies (see figure 7 that displays the share of each world region in the total appearance of industrial and academic players in the 8 energy thematic fields identified).

FIGURE 7 ► Overview of the results of the Top 10 Energy Innovators in the 8 distinct thematic fields, for industrial and academic players[133]

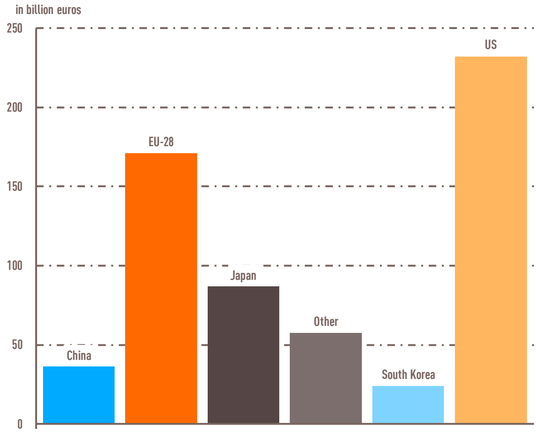


Source: T. Pellerin-Carlin and P. Serkine, Jacques Delors Institute, data from KIC InnoEnergy

Focusing on European businesses, cross-sector EU business R&D expenditure are the 2nd highest in the world, yet significantly lower than in the USA (figure 8).

130. David Ewalt, *The world's most innovative research institutions*, Reuters, 8 March 2016.
131. Another illustration could be that 25 of the 56 Fields medals (the Nobel Price equivalent for Mathematics) are EU citizens, the US comes n°2 with 14.
132. KIC InnoEnergy & Questel Consulting, *Top 10 Energy Innovators in 100 Energy Priorities: A unique report mapping industrial and academic players in global competition*, January 2015. The report is based on a methodology involving several key dimensions of R&I, such as patents, scientific publications, R&D collaborations and R&D commercialisation (spin-offs, start-ups, acquisitions, licenced technologies for instance), using quantitative and qualitative measures. The report analyses 100 energy technologies, spread among 8 thematic fields. For each of the 100 energy technologies, the report provides the top 10 reference companies and the top 10 reference research institutions, with a scoring based on a methodology developed specifically for this occasion. It is available upon request, contacting Pierre Serkine by mail (pierre.serkine@innoenergy.com).
133. Figures below 5% are not shown in the graph.

FIGURE 8 ► R&D expenditure in the world from the top 2,500 companies in 2014



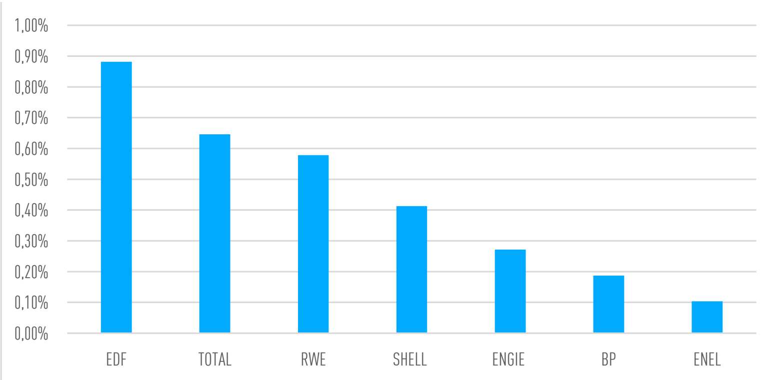
Source: T. Pellerin-Carlin and P. Serkine, Jacques Delors Institute, data from the European Commission

It is however difficult to know in which sector private R&D expenditure is invested as available statistics are insufficiently detailed. A more detailed analysis could be done by the European Energy Information Service we argued in favour in chapter 1., section 1.2.[134]

While the overall picture of European energy R&I is positive, when one looks at Europe's energy utilities, the situation is more problematic. One may even argue that if European energy incumbents are undergoing significant troubles it is because they have been consistently under-investing in R&I over the past years. Figure 9 below shows the official amount of money invested by a selected number of European energy incumbents in R&I, expressed in percentage of their annual turnover. We here see that according to their own official statistics, all those companies are investing less than 1% of their annual turnover in R&I. In other words, energy innovation in Europe does not seem to be coming from European energy utilities, but from other EU companies.

134. Jacques de Jong, Thomas Pellerin-Carlin, Jean-Arnold Vinois," *Governing the differences in the European Energy Union: EU, regional and national energy policies*", Jacques Delors Institute, Policy Paper No. 144, October 2015

FIGURE 9 ► Official amount of money invested in R&I by a selected number of European energy incumbents (% of their annual turnover)



Source: Official documents of the said companies

This is corroborated by another study led by i24c and CapGemini Consulting[135]. The EU indeed appears to have key assets in the energy transition when we look beyond utilities, at other existing EU businesses and their ability to innovate.

This is in particular true for wind turbines, a booming sector where EU businesses are the world leaders (see table 1), symbolised by the success of Vestas (DK), as well as Siemens (DE), Gamesa (ES) and Enercon (DE).

TABLE 1 ► Top 10 wind turbine manufacturers (ranked by Global Market Share)

TOP 10 Wind Turbine Manufacturers (Ranked by Global Market Share)

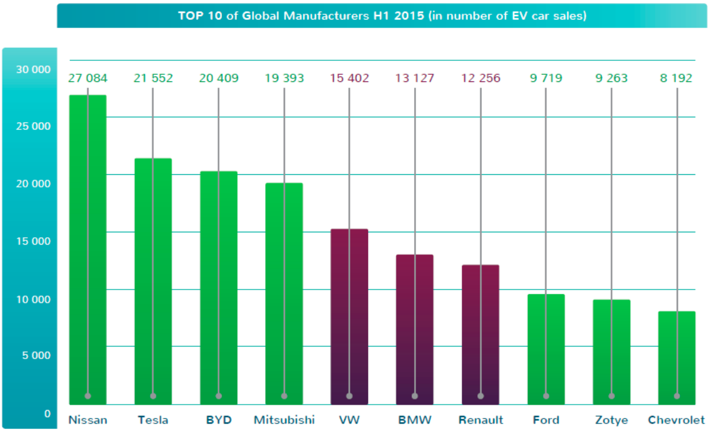
2008		2015	
1.Vestas	6.Sulzon	1.Goldwind	6.Enercon
2.GE	7.Sinovel	2.Vestas	7.Guodian
3.Gamesa	8.Goldwin	3.GE	8.Ming Yang
4.Enercon	9.Dongfang	4.Siemens	9.Envision
5.Siemens	10.Nordex	5.Gamesa	10.CSIC

Source: i24c, *Scaling up innovation in the Energy Union to meet new climate, competitiveness and societal goals*, May 2016

135. i24c, *Scaling up innovation in the Energy Union to meet new climate, competitiveness and societal goals*, May 2016

Electric vehicles are another booming market that constitutes the current best alternative to oil-based vehicles, at least for small vehicles such as cars. European car manufacturers are well positioned on this market as three of them are in the global top 10. Moreover, the current global leader is Nissan, a company that is closely associated to French car manufacturer Renault.

FIGURE 10 ► Top 10 global manufacturers, H1 2015 (in number of EV car sales)



Source: i24c, *Scaling up innovation in the Energy Union to meet new climate, competitiveness and societal goals*, May 2016

Tesla could be challenged in the future, as alternative European industrial solutions are appearing. That is the case for instance with the project of a battery gigafactory that Northvolt (led by Peter Carlsson, a former Tesla executive[136]), aims at launching in the coming years in Europe. This project could moreover benefit from the Juncker Plan (see box 2).

BOX 2 ► Northvolt: the potential for EU industrial leadership on electric vehicles[137]

Electric vehicles are one of the most promising component of the future of mobility (see chapter 1., section 1.3.1.). Developing electric vehicles is of strategic importance for Europe to make European carmakers the world leaders in electric vehicles.

136. http://www.breakit.se/artikel/6773/finansprofilen-harald-mix-backar-tesla-svenskens-nya-batterifabrik
137. The author would like to thank Guillaume Gillet for his contribution to this box.

One key component of the electric vehicle value chain is the battery. It is also one key reason for which electric vehicles remain more expensive than others. In order to reduce battery costs and conquer this booming market in Europe, the company Northvolt aims at building a gigafactory for batteries in Sweden, where it can locally access raw materials as well as cheap and low-carbon energy. Production is set to start in 2020 and eventually reach a level of sales of more than 3 billion euros.
Northvolt's 4 billion euros project is still at an early stage. If fundraising appears to be difficult, the EU should envisage to grant its financial support through non-subsidy forms, for instance via the Juncker Plan.
As the number of constructions of electric vehicles increases, the demand for batteries rises. Other gigafactories will likely be needed, thus making Northvolt's Swedish gigafactory the first of several European battery factories.

Solar is a renewable technology where Europe lost ground especially as a result of a lack of EU industrial policy for its solar PV industry in the face of Chinese dumping (see chapter 1., section 1.3.). This played a key role in the destruction of 300,000 solar jobs in the EU from 2011 to 2014[138] (see chapter 4.) and the sector is now dominated by Chinese companies (in the global top 5 of solar panel manufacturers, four companies are Chinese while the n°3 is Canadian Solar)[139]. The Chinese industrial policy was successful and trumped the EU's lack of industrial policy for this sector. In the face of Chinese dumping on solar panels, the European Commission acted to implement anti-dumping measures to protect European businesses and workers from Chinese unfair competition. Yet, those measures were opposed by several Member States who vetoed European Commission measures[140] that would have likely saved thousands of European solar industry jobs.

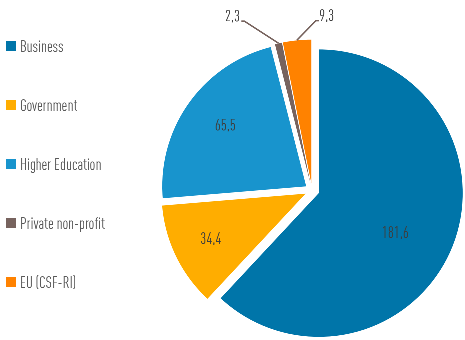
The dice have been cast for Europe's position on this generation of solar PV cells. There is however still hope for Europe to become a global solar leader if it manages to lead the next generation of solar PV cells. This may be feasible as leading academic players in the field of Solar photovoltaic system are EU organisations. Among the 10 organisations with the greatest number of solar PV patents, none are Chinese, and two are European (CEA is n°2, and Saint Gobain is n°8[141]).

138. Eurobserv'ER data
139. IHS Research (2015) Top Solar Power Industry Trends for 2015
140. Some Member States vetoed this proposal because they do not have a solar industry on their national soil and thus prefer to benefit from cheaper Chinese solar panel even at the expense of an european solar industry located in other EU Member States. Other Member States feared Chinese retaliation on other products, such as machine tools.
141. Insight-E (2015) Exploring the strengths and weaknesses of European innovation capacity within the Strategic Energy Technologies (SET) Plan

2.2.2. Existing EU R&I instruments for energy are relevant but need to be optimised

The EU has many relevant tools to foster clean energy innovation. More than two thirds of European R&D expenditures are done by businesses (see figure 11) and less than 10% are coming from the EU Budget. The challenge for the EU is thus to use EU money in a way that fosters quality national public and private investment in R&I.[142] In other words, the *raison d'être* of EU R&I policy is not primarily to fund energy R&I, but to steer it.

FIGURE 11 ► R&D expenditure in the EU by source of funds in 2014 (in billions of euros)



Source: T. Pellerin-Carlin and P. Serkine, Jacques Delors Institute, data from the European Commission and from Eurostat

The EU R&I policy has positively evolved over past decades. It moved from a project-driven approach (1983-2002) which helped developing transnational cooperation, to a more programmatic approach (2003-2013), and now closer to a policy approach[143] with Horizon 2020 (running from 2014 to 2020, see box 3) and its partial focus on societal challenges, including the energy transition[144] [145].

142. Not specific to R&I. See chapter 3.
143. Research, Innovation and Science Policy Experts High Level Group, set up by the European Commission in June 2014
144. Among those seven societal challenges three are directly related to energy, (Energy, Climate Change and Transport) while two have strong links with energy (food-agriculture, inclusive societies).
145. Vincent Reillon, *Horizon 2020 budget and implementation – a guide to the structure of the programme*, European Parliamentary Research Service, November 2015

BOX 3 ► H2020: the EU's key instrument for R&I support

H2020 is structured in three pillars: excellent science, industrial leadership and societal challenges.

H2020's first pillar is dedicated to research and knowledge building activities. One of its key tools is the European Research Council (ERC) that funds research led by teams fully created and organized by a single researcher. Its budget quickly rose to significant levels (1,6 billion euros per year). ERC schemes are not on specific calls, the researchers themselves propose the topic on a bottom-up basis to finance basic research, applied research, and some limited funding for elements that are at the frontier between applied research and innovation: the Proof of concept grants[146].

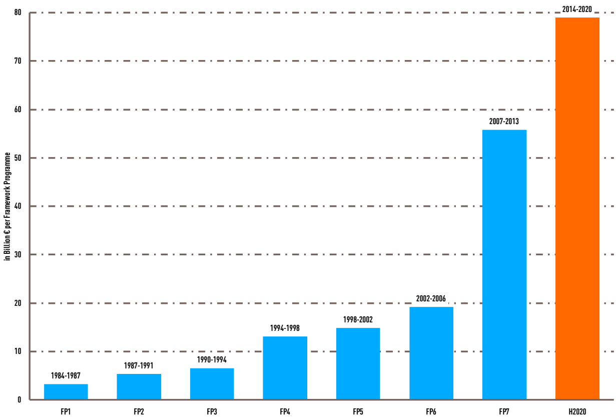
ERC support for energy-related projects has brought successes, such as a new way to produce solar cells.[147]

H2020's second pillar aims to speed up the development of technologies and innovations for European businesses. This pillar targets three specific objectives: developing Key Enabling Technologies (KETs)[148], providing financing tools for R&D activities in the private sector (loan guarantees, venture capital, direct corporate lending), and supporting specifically innovative SMEs.

H2020 brought a much welcomed evolution with **a third pillar** meant to address societal challenges (see figure 13) aligned with the Europe 2020 strategy, thus starting to bring policy orientations into the EU's innovation policy.

Some other activities lay outside H2020 three pillars, with a notable one for clean energy innovation being InnoEnergy (see box 4) that has an annual budget of 70-80 million euros.

FIGURE 12 ► Evolution of the Framework Programmes' budget between 1984 and 2020[149]



Source: T. Pellerin-Carlin and P. Serkine, Jacques Delors Institute, data from the European Commission

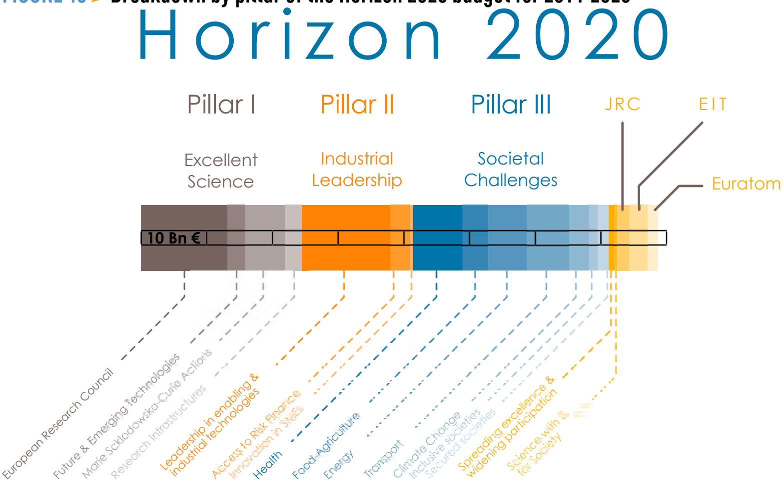
146. For a longer description of the organisation of the ERC, see Vincent Reillon, *Horizon 2020 budget and implementation – a guide to the structure of the programme*, European Parliamentary Research Service, November 2015, p.20-21

147. Yella et al., *Porphyrin-sensitized solar cells with cobalt (II/III)-based redox electrolyte exceed 12 percent efficiency*, Science, November 2011.

148. For a study on the KETs, cf. European Parliament DG for internal policies, *Horizon 2020: key enabling technologies, booster for European leadership in the manufacturing sector*, European Parliament 2014.

149. Accessible for the first seven FPs, and for the H2020 programme.

FIGURE 13 ► Breakdown by pillar of the Horizon 2020 budget for 2014-2020



Source: T. Pellerin-Carlin and P. Serkine, Jacques Delors Institute, data from the European Commission

When looking at near-market innovation, the EU has created InnoEnergy that is a successful tool to ensure interaction between public bodies, academia, businesses and start-up (see box 4).

BOX 4 ► InnoEnergy: a successful EU public-private partnership for energy innovation

The creation of the European Institute of Innovation and Technology (EIT)[150] in 2008 goes into the direction of a mission-based approach of the R&I policy, as the Knowledge and Innovation Communities (KICs), integrate the knowledge triangle at their core (see figure 12), are structured towards markets, and dedicated to societal challenges, such as energy or climate change. KICs are furthermore operating according to an impact-oriented approach using Key Performance Indicators (KPIs) to assess their action and **embracing the entrepreneurship culture.**

The official mission of the EIT is to boost the innovation process from idea to product, from lab to market, and from student to entrepreneur.[151]

In the field of the energy transition, two KICs are important (Climate and Digital) while a third one is central as it is dedicated to energy. InnoEnergy (former KIC InnoEnergy) is therefore a European PPP, initiated in 2010 by the EIT with universities and energy corporates, now InnoEnergy's shareholders. InnoEnergy is a for-profit

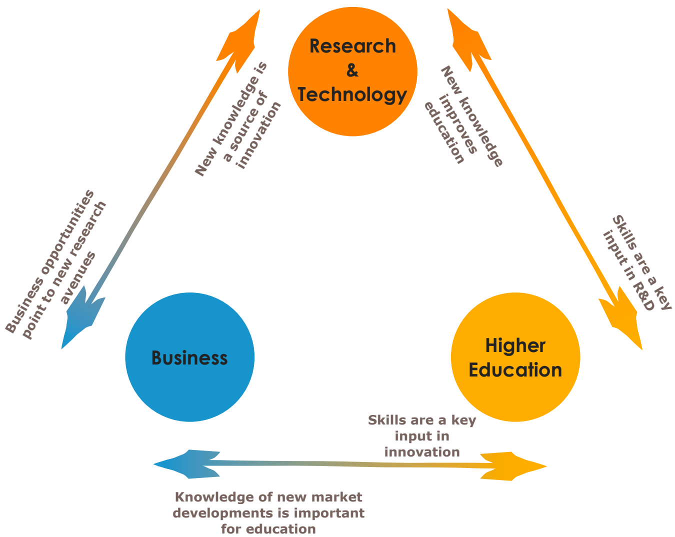
150. For a critical assessment of the EIT, see: European Court of Auditors, *The European Institute of Innovation and Technology must modify its delivery mechanisms and elements of its design to achieve the expected impact*, Special Report n°4/2016, April 2016.
151. EIT, *The EIT at a Glance*, November 2012.

but not for-dividend European company. It aims at reducing time-to-market for innovations that can reduce energy cost, decarbonise the energy system or increase energy efficiency. It has three core activities:

- **Innovative energy products** developed with InnoEnergy and partners, later sold by corporate, with a financial gain for InnoEnergy. 88 products have been created so far with forecasted sales of 3 billion euros. 1.3 billion euros have been raised by the projects. InnoEnergy has invested 157 million euros.
- **Fostering the creation of new start-ups**. 95 new start-ups have been created since 2009 with a current valuation of 100 million euros, and 171 early start-ups have been created. InnoEnergy owns shares of those start-ups.
- **Training future energy decisions makers** in a multidisciplinary way. 573 completed their training. They then enter energy companies and would ideally become top decision-makers of those companies, and incarnating the "game changers" of the very fast evolving energy landscape.

InnoEnergy is moreover embracing a more end-user centric approach to innovation as it has a dedicated work targeting end-user, with innovative approaches to foster societal appropriation of energy (see 2.3.1.).

FIGURE 14 ► The Knowledge Triangle[152]



Source: T. Pellerin-Carlin and P. Serkine, Jacques Delors Institute, adapted from EIT (2012)

152. Adapted from European Institute of Innovation and Technology, *Catalysing innovation in the knowledge triangle. Practices from the EIT knowledge and innovation communities*, 2012

2.2.3. Europe should create its own energy innovation path to outperform the US

Many European decisions makers admire the US innovation ecosystem. While there are many legitimate praises to be made towards the US system for innovation, it is the wrong model for energy innovation (see 2.2.3.1.). China and India moreover appear as increasingly important players in energy innovation and thus as rising competitors to Europe's clean energy leaders. In this context, the EU should set its own path to outperform its competitors in the global clean energy race.

2.2.3.1. The US "start-ups only" model has shortcomings and should not be mimicked by the EU

The US model for business innovation relies on start-ups[153] and a lot of attention is dedicated to the creation of unicorns[154]. Yet, at least for the energy sector, start-ups are no panacea. Two thirds of the jobs created by early-stage companies, such as start-ups, are destroyed in the first five years[155]. Such job destruction has a human and social costs, and it is also a waste of time, human and economic resources.

Davila et al. identify eight different possible explanations for this destruction. Three of them would most likely exist at a much lower level if the underlying innovations were developed inside or under the responsibility of a well-established company rather than within a start-up:

- start-ups that open new markets, in which established players subsequently enter and aggressively compete with deeper pockets, even acquiring some of these start-ups to catch up the pace.
- some start-ups can grow rapidly on non-profitable long-term business models, which corresponds to a temporary revenue transfer from the incumbents to the newcomer, until the latter stops being supported by investors.
- litigation risks can compromise fundraising by reducing the interest of potential investors.

153. Start-ups in general and unicorns in particular are considered to be the engine of the new economy. Yet, recent evolutions suggest that this may constitute a bubble about to burst. Cf. Thomas Pellerin-Carlin and Pierre Serkine, *op.cit.* p. 5-6.

154. A unicorn is a young company owned by venture capital firms and valued over 1 billion dollars. When a unicorn makes an Initial Public Offering (IPO), it stops being owned by venture capital firms only, thus exiting the category. Unicorns can thus be seen as a bet venture capital firms make on the future, even on companies that are not profitable but are expected to grow and become profitable later on, when they would monetize their activity.

155. Their paper is an analysis about the job creation and destruction phenomenon in over 158,000 early stage companies from the UK, France, Italy, Spain, Belgium, Sweden, Norway, Finland, Japan and South Korea. See Antonio Davila, George Foster, Xiaobin He, and Carlos Shimizu, *The rise and fall of startups: Creation and destruction of revenue and jobs by young companies*. Australian Journal of Management, Vol 40 (1), 2015 pp.6-35.

A shortcoming of the US model is due to sometimes the very high Return-On-Investment (ROI) requirements set out by Venture Capital (VC) firms, which start-ups directly depend on. VC firms want to exit their investment typically in a 3 to 5 years' time span while sustainable company growth in the energy sector typically requires to think in decades rather than in years. VC can thus push early-stage companies to grow as quickly as possible, sometimes at the expense of business rationality. This leads to suboptimal development of the companies that would otherwise be able to take decision more oriented toward the mid-to-long-term.

Lonely start-ups typically cannot rely on the financial, legal and commercial backing of a big company. In most cases, they need to build everything from scratch, which limits their capacity to quickly roll-out their innovations, while energy incumbents have the financial and human capital, as well as the pre-existing customer relationship, to allow for such swift roll-out of energy innovations—provided that the company overcomes the hurdles of bureaucracies.

To finance start-ups, the current US model of venture capital (VC) has proved to be well fit to finance digital innovations, but constitutes the "wrong model for clean energy innovation"[156]. Its results are gloomy as half of the 25 billion USD invested by US VC firms between 2006 and 2011 has been lost[157] and this sector has not recovered from this. The US VC model Achilles heel for clean innovation is the reluctance from large energy corporations to acquire start-ups that have already passed important milestones but yet require years of further funding and development.

Aware of the limits of its model for energy innovation, the Obama administration created ARPA-E[158], the energy equivalent of the DARPA programme that finances US military R&I.

The EU may learn from the US as start-ups and VC are one element of the innovation ecosystem. Yet, to boost energy innovation in Europe, the EU should set its own path, one that includes patient public capital and intrapreneurship[159] (see 2.3.).

156. Gaddy Benjamin, Sivaram Varun, O'Sullivan Francis, "Venture Capital and Cleantech: the wrong model for clean energy innovation", July 2016
157. B. Gaddy, V. Sivaram and F. O'Sullivan, *ibid.*
158. For a recent analysis of ARPA-E, see Brendan Haley, *Designing the public sector to promote sustainability transitions : institutional principles and a case study of ARPA-E*, Environmental Innovation and Societal Transitions, January 2017.
159. Intrapreneurship is the fact of acting as an entrepreneur while being employed in an existing company.

2.2.3.2. The Trump administration is an opportunity for Europe to outperform the US in clean energy innovation

The Trump administration and the Republican majority in both the Congress and the Senate represent a threat to the world, but an opportunity for Europe's energy sector.

While Washington anti-energy transition lobbies (e.g. Peabody energy) were powerful before Trump, the new element now is an US Federal Government actively slowing down the energy transition—as symbolised by Donald Trump's decision to withdraw from the Paris Agreement. Yet, two elements need to be kept in mind to moderate one's perception of the impact of a Trump administration on energy:

- The US Federal State is not almighty when it comes to energy policy. US States have their own energy policies that remain largely uncoordinated and inconsistent—arguably even more inconsistent than European States' energy policies. While some US states (e.g. North Dakota, Kentucky) attempt to ensure the continuity of a dirty past others (e.g. California) are pursuing their choice for the energy transition and will continue to do so under Trump.
- The US Congress will face re-election in 2018 and Trump in 2020—unless he is impeached beforehand. It is thus unclear if Donald Trump and the Republicans will have the time to derail the energy transition, or will only fight a rear-guard action.

For European policy makers and businesses, the election of Donald Trump is an opportunity. As Donald Trump and Republicans focus public support on the outdated economic models of the fossil fuel industry, European clean energy companies have an opportunity to eliminate some of their US competitors, for instance by buying them out, repatriating US technologies into Europe and attracting US-based talents who may leave Trump's USA for a continent that puts a stronger emphasis on the necessity to develop R&I to allow a speedy and fair global energy transition. The US innovation system is moreover reliant on non-US innovators settling in the US, a situation endangered by bans on immigration. In this context, Europeans can brain-drain talents, thus boosting European companies competitiveness.[160]

160. Jack J. Phillips and Lisa Edwards, Managing talent retention: An ROI approach, John Wiley & Sons, 2008. p.1

2.2.3.3. The external dimension of EU R&I policy needs to be further strengthened

As section 2.3. argued, energy innovation is not meant only to reduce European greenhouse gas emissions, but also impact global ones. This requires a strong external dimension to the EU innovation policy (including with a focus on innovation with emerging countries see section 2.3.2.2. on frugal innovation), as recognised by ACEI.

2017 is the key opportunity for Europe to take the lead in clean energy innovation. After a pro-active Obama administration, Donald Trump's USA is stepping down on clean energy. In the meantime, the EU is co-chairing the global initiative Mission Innovation launched in 2015[161]. The EU has a unique opportunity to build synergies with the Breakthrough Energy Coalition, a private initiative launched by Bill Gates, along with other investors and financial sector seeking to make long-term private investment in breakthrough clean energy innovations[162]. This role is key to provide the patient capital that mainstream private investors tend to be reluctant to provide.

2.3. Innovation to drive the clean energy transition

Section 2.1. showed the critical importance of public sector support to R&I for a swift, competitive and fair energy transition. Section 2.2. highlighted that Europe has all the assets needed to lead the clean energy race. Section 2.3. thus turns to policy recommendations aimed at fostering clean energy innovations[163]. It (1) highlights three shortcomings the EU should fix faster, (2) argues for an end-user centric approach to energy innovation, (3) suggest a concrete way to use digital tools to test a more efficient and democratic way to allocate EU funding for innovative energy projects, and (4) proposes to develop tools to help energy incumbents in their transformation into energy transition tigers.

2.3.1. Three shortcomings need to be fixed faster

The EU has very good and generally well-funded tools to support R&I across the whole R&I value chain, from fundamental research (through the ERC) to bringing innovations to market (through InnoEnergy or others KICs). Among

161. Mission Innovation is an endeavor seeing the EU and 22 countries (including the US, China, Japan, Saudi Arabia, India, Brazil) committing to doubling their clean energy R&D investment in five years. Today, those countries represent over 80% of global clean energy R&D investment. Cf. https://www.iea.org/media/workshops/2016/egrdspacecooling/19.BobMarlay.pdf
162. https://www.technologyreview.com/s/603111/bill-gatess-1-billion-fund-will-back-radical-clean-energy-ideas/
163. This section focuses on innovation, rather than research for which the situation is by and large positive (cf. Section 2) and proposals related to research have already been made in Chapter 1 as well as in previous publications,, especially Thomas Pellerin-Carlin and Pierre Serkine, "From Distraction to Action – towards a bold Energy Union Innovation Strategy", Policy Paper No. 167, Jacques Delors Institute, June 2016.

the improvements needed for EU energy R&I to better enable the energy transition, there have been very positive evolutions, for instance with the creation of InnoEnergy (see box 4) and the European Commission November 2016 communication on "Accelerating Clean Energy Innovation" (ACEI)[164]. Through those positive developments, the EU energy R&I policy is attempting to fix three key[165] problems:

1. A persistent over-focus on technologies[166] illustrated by the Strategic Energy Technology Plan (SET Plan)[167]. While it provides an excellent state-of-art of technologies and very good insights in terms of cost and performance of the corresponding technologies[168], it is insufficient as technology alone is never the solution (see 2.3.2 on appropriation of energy & social sciences).

2. Lack of prioritisation as a result of the fact that "hardly any de-prioritisation has been done"[169]. Lobbies[170] were indeed successful in ensuring that their partial interests would not be deprioritised by decision makers[171]. While this wastes public money on doubtful projects, it did not severely constrain EU support to promising technologies as it happened at a moment when EU support to R&I was increasing (see figure 12), a situation that is changed as EU public money is made scarce and some may be tempted to deal with Brexit impacts on the EU budget by cutting EU spending, including on R&I, including R&I[172]. ACEI is a positive development as it sets four broad priorities with no mention of nuclear and Carbon Capture and Storage/Usage (CCS/CCU)[173].

164. European Commission, Accelerating Clean Energy Innovation, 30 November 2016
165. Other shortcomings could be mentioned, such as the lack of common European vision on Artificial Intelligence which is not an energy-specific issue but may drastically impact the EU energy system as well as EU R&I.
166. European Commission, Energy Technologies and Innovation communication, 2 May 2013
167. The implementation framework of the SET Plan is made of 3 pillars, namely a Steering Group composed of EU Member States in charge of the governance; the European Industrial Initiatives (EIIs) composed by EU countries; researchers and industry to better align national, European and industry goals; and the European Energy Research Alliance (EERA) that brings together EU research establishments to implement joint programmes. The EIIs are based on the European Technology Platforms (ETPs) which produce technology roadmaps as well as a transversal roadmap on materials. The SET Plan is also supported by the SET Information System (SETIS) which is coordinated by the Joint Research Centre (JRC), a European Commission in-house research service with more than 2,000 researchers from various fields, working in 7 research institutes.
168. See European Commission, Working Document on Technology Assessment, 2 May 2013
169. Matthias Weber, Dan Andrée and Patrick Llerena, *A new role for EU research and innovation in the benefit of citizens: towards an open and transformative R&I policy*, European Commission, 2015
170. For a deeper look at the organisation and influence of lobbies on EU energy policy making, see chapter 1., box 3.
171. Matthias Weber, Dan Andrée and Patrick Llerena, *A new role for EU research and innovation in the benefit of citizens: towards an open and transformative R&I policy*, European Commission, 2015, p.6
172. Eulalia Rubio and Jörg Haas, "Brexit and the EU budget: threat or opportunity?", Policy Paper No. 183, Jacques Delors Institute, January 2017
173. For a more in-depth discussion on the limited use of nuclear and CCS tecnologies for the energy transition, see Thomas Pellerin-Carlin and Pierre Serkine, "From Distraction to Action – towards a bold Energy Union Innovation Strategy", Policy Paper No. 167, Jacques Delors Institute, June 2016.

3. Despite attempts to simplify the system through pooling all R&I activities under the H2020 programme, complexity remains. H2020 indeed involves no less than 8 Commission Directorates General and the JRC when it comes to budget responsibility, and the budget is implemented by 22 different bodies[174] under different types of partnerships.[175] An illustrative example is on R&I for SMEs where the original attempt to simplify the situation through a SME instrument was not sufficient to overcome path-dependency: the instrument is fragmented into 17 distinct budget lines managed by 7 DGs[176]. Complexity is further increased by the fragmentation of national public support schemes to R&I.

On all those three elements, the EU is heading in the right direction, but it should go there faster. As the EU starts to design its post-2020 Framework Programme to support Research and Innovation, it has the opportunity to further simplify and rationalise European instruments supporting R&I.

2.3.2. An end-user centric approach to energy innovation: from NIMBYs to PIMBYs

"There's a lot of talk about drones, but people don't like them, and it's social acceptance that determines whether a robot will work".
Ahti Heinla, CEO of Starship[177]

Innovation is successful when something new to a given organisation is successfully introduced, i.e. used by its end-users. High-tech products can become utter failures if they are not built to fulfil the desire or need of an end-user while many successful innovations require little-to-no technological development (e.g. BlaBlaCar, Drivy).

Energy innovation requires an end-user-centric approach to innovation focusing on energy services (e.g. heating or mobility) rather than on technologies. In this instance, the EU could introduce more end-user centric approaches to innovation. To illustrate, this would entail that demonstration projects are not only meant to demonstrate the technological feasibility of a given project, but also its adequacy to meet end-user needs. Embracing such an end-user centric approach mitigates

174. Namely: 5 Commission DGs directly, 4 public-public partnerships, 7 public-private partnerships, 4 executive agencies, the EIT and the European Investment Bank
175. European Parliamentary Research Service, *Overview of EU Funds for research and innovation*, Briefing, September 2015
176. One challenge is therefore not to increase the existing complexity. For instance, As EU Commissioner for Research & Innovation Carlos Moedas is building an "European Innovation Council" (EIC), it is paramount to ensure that the creation of an EIC would be smoothly articulated with InnoEnergy when it comes to energy innovation, as to avoid duplications.
177. *in* Ryan Health, *Politico's EU Playbook*, 12 May 2016

the risk of developing technologies that will not be appropriated by users, while leaving aside other technologies that can be quickly appropriated by its users.[178]

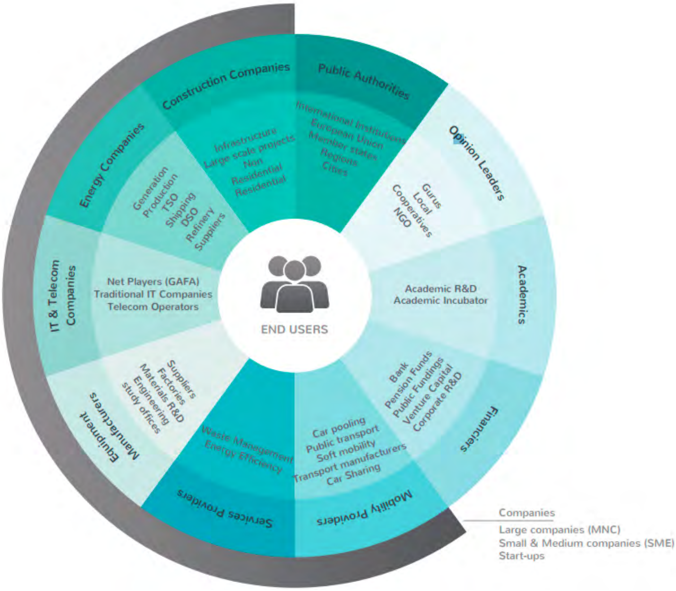
In energy R&I, attention dedicated to end-users and citizens has tended to focus on popular opposition to some energy projects (e.g. windfarms, nuclear power plants, shale gas extraction sites etc.). As citizens may oppose energy projects, a stronger focus has been put on the notion of "social acceptance" where an end-user or citizen is seen as either a passive recipient or active opponent to a technology/project. We now need to move beyond this dichotomy and embrace the notion of "societal appropriation of energy"[179] that aims at capturing the process through which citizens/end-users can actively introduce new goods and practices, and thus steer change[180]. In energy, it corresponds to an energy transition desired and powered by citizens/end-users themselves. Unlike acceptance, the agenda behind societal appropriation is not about imposing to people what they do not want, but aims at looking for ways to co-create with citizens and end-users the energy solutions of tomorrow. In short, the challenge is to enable a change from NIMBY to PIMBY.[181]

In the long term, appropriation of energy may correspond to an individual learning to consider energy as part of his/her social identity, to integrate energy in daily decisions, routines and behaviours. Appropriation of energy could for instance be acquired in childhood[182] through daily management of and recurring experiment with energy; via a process similar to the way notions like time and money are taught throughout life.[183] By raising their awareness, citizens become more likely to be better informed when they choose to remain indifferent, oppose or actively support a given energy

178. To illustrate, in the debate over choosing electric cars or hydrogen cars, leaving aside the technological debate, it is clear that electric cars are much more easily acceptable by car users. One of the reasons for this is that, while both electricity and hydrogen pose a risk to the user's safety, European users have been accustomed to managing electricity risks since their childhood by learning how to behave when confronted with them (e.g. when parents teach a child not to put his finders in an electrical outlet).
179. Thomas Pellerin-Carlin and Pierre Serkine, "From Distraction to Action – towards a bold Energy Union Innovation Strategy", Policy Paper No. 167, Jacques Delors Institute, June 2016
180. This notion is already at the core of several start-ups, such as Wivaldy, a start-up aiming at developing an user-friendly app to allow electricity consumers to gain control over their electricity consumption. It is also present in the work done by InnoEnergy (see box 4).
181. The acronym "NIMBY" means "not in my backyard" and is used to name individuals—or organisations—who favour something (e.g. wind power development) as long as it does not directly impact their lives (e.g. people opposing a windfarm from being built in their area). By contrast, our acronym "PIMBY" means "please in my backyard" and can be used to name individuals—or organisations—who suit the word to the action by both advocating for something and literally doing it (e.g. investing money in a windfarm through a crowdfunding campaign).
182. This could be achieved by the use of games or gamified techniques of teaching.
183. Energy is certainly a very complex and technical industry. However, monetary policy and money creation are also very complex processes, and it does not preclude citizens to routinely use money. Similarly, Time is a very abstract concept which is not more natural for human beings than Energy, which is not seen as an obstacle to use this notion every day.

project. This would also ease the inclusion of end-users at the core of an enlarged ecosystem of energy innovation stakeholders (see figure 15)[184].

FIGURE 15 ► An enlarged ecosystem of energy innovation stakeholders



Source: i24c, *Scaling up innovation in the Energy Union to meet new climate, competitiveness and societal goals,* May 2016

184. For an in-depth analysis of innovation ecosystems, see in particular i24c and Carbon Trust, *Industrial innovations driven by multi-stakeholder ecosystems*, September 2016.

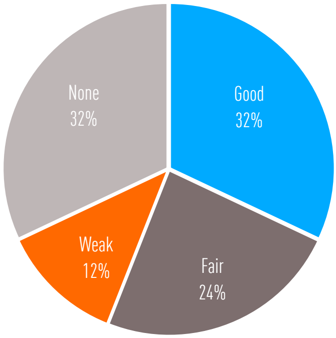
2.3.2.1. Social sciences enable a better energy innovation

In 2007 and 2008 a group of social scientists published two academic articles[185] showing that providing social norm information induces people to reduce their energy consumption. Their work inspired what has become one of the top clean energy start-ups in the world, Opower, recently bought by Oracle for 532 million USD[186]. Opower's success highlights that technology is an optional component for innovation, while end-user appropriation is critical. This suggests that social sciences are important components for innovation in general and energy innovation in particular. Their approaches[187] help to increase the chances that a given innovation tackles societal needs, as well as increase the chances of delivering a cost-efficient and applicable solution.

Yet, when it comes to EU funding, social sciences are too neglected. Only 6% of the EU H2020 funding goes to all "social sciences and humanities" (SSH)[188] with the best-integrated SSH disciplines being economics, business and marketing. Disciplines like geography or anthropology, that are critical to understand energy behaviours are nearly absent from H2020 funding[189]. What is even more worrying is that, according to the European Commission, only a third of the "projects funded under topics flagged for SSH[190] show good integration of SSH"[191], while SSH integration is judged to be "weak" in 12% of the projects and inexistent in a third of them (see figure 16).

185. Wesley Schultz et al., "The constructive, destructive and reconstructive power of social norms", *Psychological Science*, 2007. Jessica Nolan et al., "Normative influence is underdetected", *Personality and social psychology bulletin*, 2008
186. https://www.greentechmedia.com/articles/read/oracle-acquires-opower
187. For a literature review on social sciences insights for understanding energy consumption behaviours, cf. Paul Burger et al., *Advances and understanding energy consumption behaviors and the governance of its change: outline of an integrated framework*, Frontiers in energy research, Vol 3, Article 29, June 2015.
188. SSH are defined as the following disciplines: anthropology, economics, business, marketing, demography, geography, education, communication, history, archaeology, ethics, interpretation, translation, languages, cultures, literature, linguistics, philosophy, religion, theology, political science, public administration, law, psychology, sociology. Cf. European Commission, *Integration of social sciences and humanities in horizon 2020*, 2015. p.8
189. European Commission, *Integration of social sciences and humanities in horizon 2020*, 2015., p. 9 & p. 14
190. It is indeed worth pointing out that this poor performance concerns only the projects flagged for SSH, precisely the ones that should have a very good integration of SSH.
191. The quality of the integration of SSH is assessed "in terms of share of partners, budget allocated to them, inclusion of explicit and purposeful contributions, and variety of disciplines involved". European Commission, *Integration of social sciences and humanities in horizon 2020*, 2015., p. 16. Data shown in the graph exclude the projects financed under the part SC6 of H2020 as this section is *de facto* devoted to SSH and inclusion is therefore 100% good. Including SC6 would however not significantly alter the assessment as the share of projects judged to have a good integration of SSH rise from 32% to 40%, while all others decline: Fair from 24 to 21%, weak from 12 to 11% and None from 32 to 28%.

FIGURE 16 ► Quality of integration of Social Sciences and Humanities in EU projects flagged for SSH



Source: Thomas Pellerin-Carlin and Pierre Serkine, based on the data of the European Commission, *Integration of social sciences and humanities in horizon 2020*, 2015

A holistic understanding of the drivers behind individual and collective energy choices is moreover currently lacking[192]. To address this gap, the European Commission recently decided to invest 10 million euros to finance three research projects to help filling this gap[193], which should thus be partially filled by 2019.

Beyond already existing initiatives to foster a genuine interdisciplinary approach to energy challenges, the EU could:

- Require students benefitting from an Erasmus grant to have a minor in another discipline than their major one, at least during their year of study abroad. For instance, an automotive engineer could opt for a minor in anthropology.
- Invite EU publically funded teaching and research institutions, such as the College of Europe[194], or the European University Institute to have interdisciplinary master or doctoral programmes on a given topic, such as energy-climate issues.

192. Paul Burger et al., *Advances and understanding energy consumption behaviors and the governance of its change: outline of an integrated framework*, Frontiers in energy research, Vol 3, Article 29, June 2015
193. Those projects started in late-2016. The first one to start is named ENABLE.EU, in which the chapter's author is taking part. The two others are named ECHOES and ENERGISE.
194. The proposal for the creation of a "College of Europe for energy" originates from Michel Derdevet, *Energie – l'Europe en réseaux*, La Documentation française, February 2015. Furthermore, the College of Europe now organises since 2016 a two-weeks interdisciplinary training on the Energy Union

- Further use the Marie Sklodowska Curie Actions[195] to support transdisciplinary mobility of researchers, rather than focusing mostly on geographical mobility.
- For SSH flagged H2020 projects, a social science analysis of the topic could be required to assess the proposal sent by H2020 grant applicants, as to signal the importance of SSH.

2.3.2.2. Frugal Innovation for a fair energy transition in European and emerging countries

"Growing global energy needs, in particular in emerging markets, present significant export opportunities for European companies to supply low-emission technologies, including, where applicable, "frugal" innovations that are adapted to local conditions. New strategic partnerships, especially with emerging economies, are needed to drive innovation and create markets."
European Commission, *Accelerating Clean Energy Innovation communication*, 30 November 2016

Several academics have already looked at ways to include social science analysis as part of a renewed approach to innovation. One such example is the notion of frugal innovation[196], which is the process of simplification of a product (removing nonessential features). Such approach to innovation can play a key role in the energy transition, in Europe but also for emerging countries.

The challenge for emerging countries is to leapfrog from poverty to clean prosperity, without going through a stage of dirty economy (see section 2.1.3.). For Europe, in line with the United Nations Sustainable Development Goals, the challenge is to help emerging countries to ensure sustainable energy for all, promote human development while tackling climate change and creating jobs in Europe and in emerging countries.

In emerging countries, technological transfer is not always straightforward, local specificities hinder to directly apply similar processes and technologies, while they foster approaches that would fail or underperform in industrialised nations. Different sets of skills, infrastructures, natural resources, can be an

195. Those actions currently support the mobility and training of European researchers. Our redirection proposal would for instance mean that the support of a Marie Sklodowska Curie Action would be granted to a researcher's geographical mobility only if it includes a transdisciplinary mobility.
196. Stephan Winterhalter, *Resource-Constrained Innovation and Business Models in Emerging Markets*, PhD diss., University of St. Gallen, 2015. See also, Navi Radjou and Jaideep Prabhu, *Frugal Innovation – how to do more with less*, The Economist Books, 2015. Other terms than "frugal innovation" exist and have in common to foster the exchanges between innovation in emerging and in developed countries: cost innovation, low-cost innovation, good-enough innovation, jugaad innovation, Gandhian innovation, and reverse innovation.

opportunity to think outside the box, thus helping to design innovative products, practices and business models. To illustrate, the "pay-as-you-go" billing scheme for electricity (i.e. a prepaid purchase of a certain amount of electricity) is a sound way to bring light and charging points for mobile phones in remote areas. In the same vein, the lack of existing electricity network is an opportunity for decentralised renewable electricity generation. Frugal innovation is thus key to help European companies to conquer emerging markets, but it is also associated to reverse innovation: when an innovation first conquers emerging markets before being transferred to developed countries.

Frugal innovation, now endorsed as an element of the Energy Union by the ACEI communication (see quotation supra) should therefore be actively promoted, not only to support emerging countries in developing a low carbon energy system for their economy, creating jobs, and help European companies to enter new markets, but also to get inspiration from these constrained regions to bring innovations back to Europe. To promote frugal innovation, the EU might further develop energy innovation in its external relations, using in particular its outermost regions as creators, test beds and showcases for innovations[197] (see chapter 2.3.4.) than can then be implemented in third countries in collaboration with EEAS, Member States embassies and local partners who can assess the situation on the ground and articulate a holistic approach including trade, energy, industry and development aid tools. In that regard, the European Commission should take the lead to propose an initiative for frugal innovation, with a focus on the clean energy transition, to be built and implemented with Member States and financially supported by the EIB and the national development banks/agencies[198].

2.3.3. A citizen-based platform for an efficient and democratic way to foster breakthrough innovation[199]

Post-2016 European political context is shaped by Brexit, Trump and the persistence of powerful nationalist forces in key countries. Many question the political

197. Enrico Letta, Bertrand Piccard, Herman Van Rompuy, "Why and how Europe should become the world leader of renewable energy?", Jacques Delors Institute, 7 February 2017
198. For a more in-depth discussion on the role of frugal innovation for the energy transition, see Thomas Pellerin-Carlin and Pierre Serkine, "From Distraction to Action – towards a bold Energy Union Innovation Strategy", Policy Paper No. 167, Jacques Delors Institute, June 2016.
199. The author would like to thank Pierre Serkine who has had the original idea for this proposal. A more holistic presentation of this proposal can be found in Thomas Pellerin-Carlin and Pierre Serkine, "From Distraction to Action – towards a bold Energy Union Innovation Strategy", Policy Paper No. 167, Jacques Delors Institute, June 2016.

establishment's ability to hear what a significant portion of European peoples ask for: having a more direct say in policy making. For energy R&I, this could take the form of a proposal that adopts an open-innovation approach, gives citizens the power to co-create, select, co-finance and implement energy innovation, while including the expertise of innovative firms, researchers and laboratories.

2.3.3.1. Co-creating ideas thanks to crowdsourcing

Crowdsourcing can be used to co-create an idea: the original idea is proposed, contributors collaborate, share comments and suggestions for improvement. This can be done via an open digital platform, inspired by tools already existing in companies like Engie, EDP or ENEL.

The EU should therefore launch a digital platform where ideas can be freely co-created by everyone. It would seek to have a large number of diverse participants with various backgrounds and cultures to foster "outside the box" thinking and cross-fertilization. Crowdsourcing also leads to an increased quality of the top ideas produced through this process[200]. In other words, crowdsourcing enables the innovation process to foster more and better disruptive innovations, i.e. the innovations that are the most likely to help Europe lead the global clean energy race.

Involving more people in the process is also essential to favour a swift and efficient implementation of innovations. As suggested by the "IKEA effect"[201]: the more we contribute to an endeavour, the more we tend to value its outcome. In the end, contributors to this platform are likely to become grassroots backers of innovation. To engage many and diverse citizens, gamification[202] mechanics should be used on this platform, to cultivate interdisciplinarity, promote and reward contributors.

2.3.3.2. Selecting ideas through democratic selection

The selection of the innovations worth pursuing should resort to the very foundation of our democracies: a vote by all the platform's contributors.

200. Andrew King and Karim R. Lakhani, *Using Open Innovation to Identify the Best Ideas*, MIT Sloan Management Review, fall 2013, pp.41-48
201. Norton, M.I., Mochon, D. and Ariely, D., 2011. *The'IKEA effect': When labour leads to love*. Harvard Business School Marketing Unit Working Paper, (11-091)
202. Contrary to a game, which is made to entertain users, gamification is made to engage them, using gaming mechanics such as collaboration, competition and rewarding, to channel and coordinate participants. The gamification dimension could also allow to institutionalise the multidisciplinarity and social diversity in the platform, through the use of various badges (for the socio-economic background, the gender, the age, the type of professional background etc.).

Voting can be a very quick process that reduces time-to-market, a key critic to current EU way of funding innovation. Indeed, H2020 calls may take up to two years between the start of the call and the beginning of a project, while such platform could foster the selection of proposals in only a few weeks or months.

Voting is also helpful in ensuring a good fit between market needs (represented by citizens themselves) and innovations. It moreover helps guaranteeing the democratic legitimacy of the choice of each project, which is likely to enhance the social acceptance and social desirability of the selected projects.

2.3.3.3. Financing innovations through crowdfunding and citizen allocation of EU funding

To finance innovation, crowdfunding[203] already plays a massive role that can be more important than even government public support[204]. It also effectively empowers citizens by involving them directly[205].

Crowdfunding moreover helps reducing time to market and building a community of users[206] who can actively support the innovation project and play an ambassador role. It is a suitable solution to coordinate multi-level, multi-discipline and multi-national players, simplify the governance and improve the funding of innovation by avoiding overlaps and gaps.

In practice, this platform would gather four categories of funders.

- EU citizens who fund the projects they like best.
- EU public money would be allocated directly by citizens, in the form of a grant or a guarantee. The allocation rule should be very simple, e.g. for each euro invested by a citizen in a project, the EU pours one euro or; alternatively, each citizen using the platform could attribute a small amount of EU money to the project he/she likes best[207].

203. Crowdfunding pools financial contributions from a large number of people.
204. In 2016 in the UK, seed crowfunding provided 40% more funding to UK businesses than the flagship British Government Start Up Loans initiative. See Hunter Ruthven, *Seed crowdfunding outperforms government's Start up Loans scheme in 2016*, Business Advice, 18 January 2017.
205. Crowdfunding schemes varies depending on the platforms, as it can be equity-based crowdfunding (energy cooperative) or lending-based crowdfunding with a guaranteed return on investment. Whatever the scheme, this approach enhances the appropriation of energy infrastructure, mitigating the NIMBY effect and contributing to transform it into a PIMBY effect. Cf. Kristiaan Versteeg, *Tracking renewable energy crowdfunding*, Solar Plaza, 15 September 2015.
206. See for instance, Peter Hesseldahl, *The new normal: from products to platforms and processes*, 10 September 2014
207. Lessons could be drawn from already existing initiatives done by European cities, such as the city of Paris and its participatory allocation of 500 million euros.

- Business angels and venture capitalists should be involved to increase the leverage effect and demonstrate that citizen-chosen projects can be good investment opportunities.
- Local authorities, especially cities, can co-finance a project, especially those requiring to engage local communities to test the innovation before full deployment or commercialization.

2.3.3.4. Implementing innovations with start-ups or intrapreneurship

Once the energy innovation project is conceptualised, selected and financed, it still has a long way to go to fulfil its potential to become a successful innovation. The two common channels are the creation of a start-up or through intrapreneurship (see section 2.3.4.).

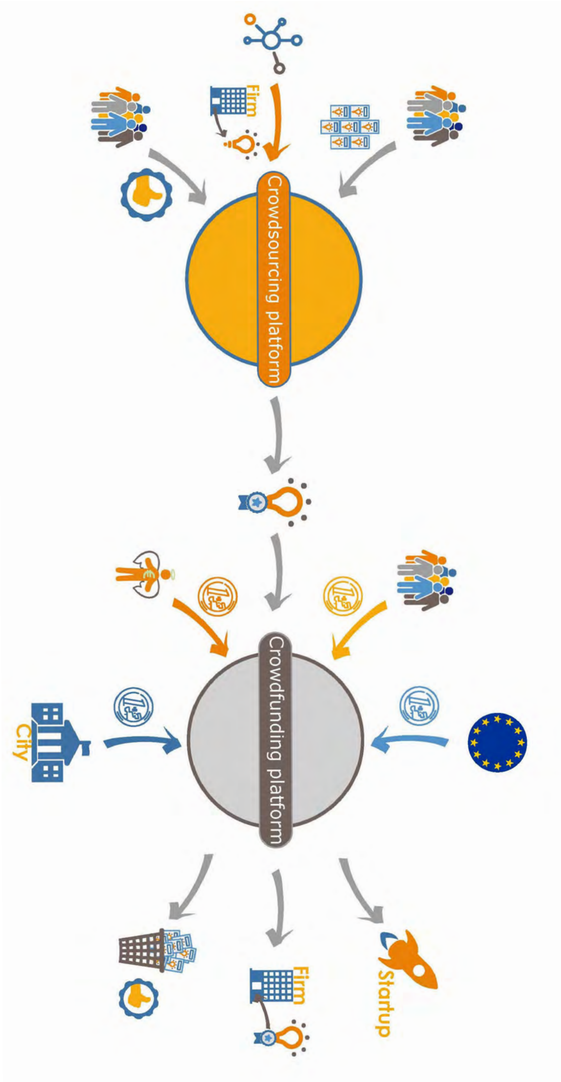
Figure 17 visually summarises our entire proposal. With citizens truly at its core, it may allow the EU to support an innovation process that is more democratic, but also more effective and efficient. Citizen involvement is indeed a way to mitigate the over-influence of some lobbies as engaged citizens would help policy makers to adopt policies serving the European peoples, not merely fitting the partial interests of current main energy stakeholders. It would moreover increase the chances that citizens not simply accept but desire and power the energy transition[208], enabling a change from NIMBY to PIMBY.

In more operational terms, this proposal should first be tested to empirically identify its innovative, political and economic value. The European Commission can launch a pilot-project to be operational in 2018, with tens of millions of euros to have real EU money to be allocated by EU citizens. If successful, it could be scaled-up in view of the next Multiannual Financial Framework 2021-2028.

If well implemented, this proposal may yield important strategic results: more and better energy transition innovation projects; a real-life demonstration that the EU is at the forefront of innovative thinking and wishes to give European citizens a greater and more direct say in concrete decisions.

208. For instance, in Germany, around half of the renewable capacity installed between 2000 and 2010 has been installed by citizens. See Noémie Poize and Andreas Rudinger, *Projets citoyens pour la production d'énergie renouvelable : une comparaison France-Allemagne*, IDDRI working Papers, 2014.

FIGURE 17 ► An EU crowd-based digital platform to boost innovation in an efficient and democratic manner



Source: T. Pellerin-Carlin and P. Serkine, Jacques Delors Institute

2.3.4. Transforming incumbents into energy transition tigers: corporate venturing and intrapreneurship

"Corporate entrepreneurship is envisioned to be a process that can facilitate firms' efforts to constantly innovate and effectively cope with the competitive realities that companies encounter when competing in world markets."
Donald Kuratko [209]

Competitiveness by and large rests on the capacity for businesses to "do what no one else can do[210]", something that is first and foremost characterized by their capacity to innovate. An "open and transformative R&I policy, [can make] Europe world leader in the new networked innovation economy, but geared towards the benefit of the citizens. This change will be an important part of a new EU R&I policy in the revised Europe 2020 strategy to ensure that the European recovery is sustainable, based on sustainable growth, knowledge-intensive society, not just the old growth model where productivity is achieved through cost reduction"[211].

This entails a paradigm shift. With innovation at its core, competitiveness is no longer limited to being a defensive policy meant to allow national companies to do what everybody else does, but cheaper—through smaller wages, lesser taxes, smaller energy prices etc. With innovation at its core, competitiveness can also be an offensive policy meant to help European workers and businesses to innovate and conquer European and global markets (see 2.1.2.)

Energy incumbents need corporate venturing[212] to transform their business models to avoid economic collapse—and the related human, social and economic costs. Several energy incumbents[213] are already working with start-ups in order to innovate (see box 5), others are acquiring start-ups or developing in-house innovation hubs. All those tools can be complementary, and can be articulated with intrapreneuship.

209. Donald Kuratko, *The entrepreneurial imperative of the 21st century*, Business Horizons, 2009, p.422
210. Andrea Ovans, *What is Strategy Again?*, Harvard Business Review, May 2015
211. Matthias Weber, Dan Andrée and Patrick Llerena, *A new role for EU research and innovation in the benefit of citizens: towards an open and transformative R&I policy*, European Commission, 2015
212. Corporate venturing and strategic entrepreneurship are the two pillars of what is called corporate entrepreneurship. The latter can be seen as the integration of entrepreneurial mind-set into the processes, values, mission, and structure of organisations, while the former deals with the addition of new businesses to these organisations. c.f. Donald Kuratko, *The entrepreneurial imperative of the 21st century*, Business Horizons, 2009, p.421-428
213. For a list of companies that have set up their own venture capital and/or have set up open innovation platforms, cf. i24c, Scaling up innovation in the Energy Union to meet new climate, competitiveness and societal goals, May 2016.

BOX 5 ► NUMA: when start-ups, incumbents and governments work together for the energy transition[214]

NUMA is a global innovation network that accompanies start-ups, public institutions and corporates. Its key mission is to use digital tools (data) to answer human challenges ("NUM" stands for "numérique", the French word for digital, and "UMA" stands for "human"). Created in Paris in 2000, it now has offices in eight cities in the world (Paris, Bangalore, Barcelona, Berlin, Casablanca, Mexico, Moscow and New York). NUMA focuses on building synergies between start-ups, corporates and local authorities like cities to solve the global problems of 2030, with activities in several areas including energy, transport and smart cities. The aim is to combine the speed and innovative capacity of start-ups with the critical mass of big organisations, be they public (e.g. cities) or private (e.g. corporates).
The example of NUMA shows that start-ups can be particularly useful not as stand-alone solutions, but as a critical element of a broader innovation ecosystem, working with cities (through their DataCity programme) and corporates (including energy incumbents). As such, NUMA's experience could inspire the new framework programme for EU research and Innovation that will be implemented between 2021 and 2027 and is currently being conceptualised by a high level group of experts created by the European Commission and led by Pascal Lamy, who should publish its work by June 2017[215].

Intrapreneurship is about creating internal processes to promote innovation by company employees, with the aim of having the said company bringing those innovations to the market. Intrapreneurship is complementary to start-ups as it brings additional benefits to a "start-up only" path: less job destruction, more sustainable company growth, more massive deployment of successful innovations, and the ability to tap into the employee's innovative potential.

Intrapreneurship can unleash the dormant innovative potential of company employees. Not harnessing it is an opportunity cost that make European businesses less competitive than they could be. As a rule of thumb, intrapreneurship is efficient when an environment prone to entrepreneurial initiatives (e.g. flexibility, openness, promotive environment, and collegiality) is created by a company that genuinely embraces the concept of "active innovation"[216].

In 1948, 3M Corp. created its intrapreneuship programme[217], which led to the creation of the "Post-It". In recent years, Facebook created its own programme, from

214. The author would like to thank Clémence Fisher and Nicolas Enjalbert for their key contribution and comments for this box.
215. http://ec.europa.eu/research/index.cfm?pg=newsalert&year=2016&na=na-220916
216. Dirk Meissner and Maxim Kotsemir, *Conceptualizing the innovation process towards the 'active innovation paradigm'—trends and outlook*, Journal of Innovation and Entrepreneurship, 5(1),2016
217. It is a permitted bootlegging policy in which employees can spend 15% of their time to work on their own ideas.

which emerged the idea of the "like" icon. Google also has its "20% time" allowing its employees to spend 1 day a week on a personal idea they have. Beyond that, "Hackathons" are another kind of initiative implemented by some companies to harness creativity and valorise the entrepreneurial initiatives of employees.[218]

Intrapreneuship is also a key to attract, develop and retain talents[219] in Europe and within a specific company. The implementation of an intrapreneurship programme can moreover provide a feeling of accomplishment, fulfil the desire of having a useful work and be used to reward employees, thus enhancing the quality of a given job.[220]

To promote intrapreneuship, public authorities can first help legitimise this tool in the energy industry. As many energy incumbents are still largely owned by EU Member States, those states, as forward-looking shareholders, can ask for the development of intrapreneuship programmes within publically owned companies[221]. Public authorities could also provide incentives for companies to get to the next step: fast prototyping of the best ideas via structures such as Fab Labs[222].

CONCLUSION

The energy transition is a critical challenge in the 21st century. In Europe, the energy transition has already started and, if European energy business are to survive in this new world, they must innovate to adapt. This is actually a key opportunity for the European economy: by making Europe the place for global energy transition leaders, it allows European workers to reap the benefits of leading the booming global energy transition market, while allowing European innovation to foster the global energy transition needed to fight climate change. To enable the shift from conservative European energy incumbents

218. Internal hackhatons are used by companies such as Facebook, Google, or Microsoft. The well-known button "Like" popularized by Facebook is arguably the most famous outcome of a hackathon.
219. Jack Phillips, and Lisa Edwards, *Managing talent retention: An ROI approach*, John Wiley & Sons, 2008. p.1
220. "A powerful employee value proposition includes tangible and intangible elements, such as an inspiring mission, an appealing culture in which talent flourishes, exciting challenges, a high degree of freedom and autonomy, career advancement and growth opportunities, and a great boss or mentor." from Günter Stahl, et al. *Six principles of effective global talent management*, Sloan Management Review 53, No.2, 2012.
221. For instance, the French company La Poste—the former postal monopoly—has established an intrapreneurship programme since 2014, leading to the creation of several start-ups by its employees under the umbrella of La Poste. See Chloé Dussapt, « La Poste lance ses start-up grâce à l'intraprenariat », *Challenges*, 16 June 2016.
222. A Fab Lab is a workshop where machines, materials and electronic tools are available for people to design and produce unique goods through digital fabrication. A bottom-up approach to technology, Fab Labs aim to unlock technological innovation and promote social engineering.

to energy transition tigers, public support is critical and should come from the EU, Member States and local authorities.

EU academia and businesses are already well-positioned to lead the global clean energy race. EU R&I instruments have evolved very positively in recent years and should be further improved, especially as the Trump administration opens a window of opportunity for Europe to outperform the US and become the global centre of energy innovation, with all the economic, scientific and soft power assets such a position yields.

To deliver a more democratic, competitive, fairer and swifter energy transition, the EU should not copy the US model, but proudly develop an European energy innovation path, walking on its two legs: start-ups and intrapreneuship, powered by creative research, enabled by patient EU, national and local public support, with the aim of fostering the transformation of energy incumbents into the energy transition tigers, able to roll-out innovations in a swift and massive way.

In more concrete terms, this entails to adopt a more end-user centric approach (rather than a technology-centric approach) to innovation, to work on societal appropriation of energy, embed social sciences' findings in energy innovation and develop frugal innovation approaches for EU and emerging markets. It also entails to innovate within EU innovation policy, for instance via testing an EU-supported platform where ideas would be co-created, democratically selected, crowdfinanced, with a contribution from the EU budget allocated directly by citizens. To increase the chances of successful adoption of innovations, intrapreneurship should be promoted as a complementary tool to European start-ups in the energy transition.

All in all, the EU ship has a capable crew of entrepreneurs and researchers, and enough public and private investment capacity that can blow in its sail to safely navigate towards a clean energy future. The Energy Union provides the right compass, but Europe should set its own course: ignoring the US Sirens' songs and avoiding the reefs of immobilism, the EU must truly place citizens at the helm to keep the heading. Only then can Europe lead the global clean energy race.

ANNEX 1 : A PARADIGM SHIFT OF OUR ECONOMY DRIVEN BY FOUR MEGATRENDS