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Optimising the road to a low carbon competitive energy sector in Europe

Key messages:

- To ensure an affordable future energy supply and combat climate change, a global transition of the energy sector is needed. Europe has to make its choices in that global context. This process will take several decades and will be surrounded with many uncertainties.
- Reinforcing and expanding the European emission trading scheme (ETS) to include other sectors and regions in coming decades is the preferred element in a robust regulatory framework. Stable and higher carbon prices are an essential condition for low carbon investment planning and many other Member State policies. When prices are high and stable the market will seek the most cost efficient mix.
- Renewables and energy efficiency are important solutions for the long run. Assuming the ETS will be significantly strengthened overall EU targets and policies for renewable and efficiency beyond 2020 have to fit within the ETS framework.
- If renewable energy and energy efficiency targets for separate MS and sectors are set, they need to be flexible in order to avoid suboptimal economic outcomes. After 2020 a new harmonised and flexible EU approach is needed to address technological and cost uncertainties.
- Innovation policies need to be enhanced complementary to the regulatory framework. They should be based on a technologically and economically sound long-term perspective. They should focus on comparative advantages of the EU and its Member states.
- Large, unprecedented upfront investment is required, which can only be induced by building confidence among investors, consumers and authorities. First movers in new energy infrastructures need customized policy support.
- The EU energy roadmap has to be adjustable to global economic, structural, technological and policy developments. Thus, it will provide guidance for investors, consumers and governments.

Introduction

February 4th 2011, representatives of 27 EU Member States gathered in Brussels at the first summit dedicated to the future of the European energy market. They reiterated that safe, secure, sustainable and affordable energy contributing to European competitiveness remains a priority for Europe. The Roadmap energy 2050 will have to yield the framework for long-term directions, goals, strategy and action. Currently, the issue of consistency of goals for greenhouse gases, energy efficiency and renewables is discussed, as are new approaches to further increase renewables in Europe. The Roadmap will have to include a clear and robust rationale for a future policy mix that facilitates economic partners in making the right choices for new energy systems in Europe.

In the existing strategy for competitive, sustainable and secure energy (EC 2010a) the Commission stressed the urgency of far-reaching changes in energy production, use, and supply. The stated priorities are energy efficiency, integrated markets, energy security, innovation and external actions. In March 2011, an energy efficiency plan was proposed with measures leading to 20% efficiency improvement in 2020 (EC 2011a). Moreover, in March 2011 the Commission launched the Roadmap for a Low Carbon Economy in 2050 (EC 2011b). The domestic greenhouse gas reduction target, based on international negotiations, was set at 80% compared to 1990. For energy related CO_2 emissions, the envisaged reduction is even larger. The Roadmap also includes indications for sector reductions in 2030 and 2050. An energy transition is clearly needed. Competitiveness, energy security and sustainability are the goals that need to be achieved. At the same time, these are also the conditions that policies and measures aimed at energy transition have to meet. In the long-term process of energy transition, considerations of competition, sustainability and security may actually slow down the implementation of policies and measures. Examples include biomass sustainability, carbon leakage and nuclear risks. Recent German decisions on nuclear power may favour coal, but can also speed up the introduction of renewables and efficient gas-fired power systems. Setting broadly accepted, well-founded long-term targets and adequate conditions for all viable technologies are a key to success. Since several important programmes were recently launched, this paper will evaluate their optimality for the three basic goals: competitive, sustainable and secure.

The key question is:

Do current and envisaged EU energy and climate policies allow for optimal introduction of new energy technologies towards a globally competitive, sustainable and secure energy system?

To analyse and evaluate the current European programmes and strategies, the following objectives for reinforcing policies have been signalled by the Dutch government:

- Well-performing electricity and gas markets and infrastructures and removing market barriers for trading at competitive prices.
- Establishing a concrete strategy for realising the infrastructure that is needed to facilitate this market, allowing for intermittency, flexibility and diversified supply.
- Realising a well-performing ETS and prevention of carbon leakage to provide a stable investment climate and a level playing field for CO_2.
- Facilitating innovation in sectors and Member States with comparative advantages and a transnational approach where this is more effective and efficient.
- Focussing on cost-effective energy savings policies in non-ETS sectors and the role of national and local governments and economic partners.
- Establishing a simple and robust regulatory framework with fewer legislative and administrative burdens and without overlaps or conflicting targets.

In the following sections, current and future EU policies will be analysed for these objectives. The analysis should not be seen as an evaluation, but rather as a set of suggestions on how to better achieve the fundamental goals. A first step is to explore the roadmaps and the possible targets. Addressing various market failures then becomes the line of reasoning in this essay.

Roadmaps and target setting

Exploring future energy systems and stating a clear ambition constitute a vital first step in policy making. A greenhouse gas reduction target of 80% in 2050 is highly ambitious, but it is not a policy in itself. Neither is setting separate targets or obligations for sectors, countries or for renewables or energy efficiency. It is the instruments that make it happen. Setting separate Member State targets for renewables or energy efficiency provides guidance on what is needed for the overall EU goals. However, Member States may need to make other choices to achieve competitiveness, sustainability and security for the EU.

There is no single low carbon solution

On the road to a low carbon economy, setting a deep reduction obligation and creating a carbon market may not be sufficient. Stimulating technological solutions like renewables, energy efficiency and CCS is necessary to spur technological development and mitigate costs. Moreover, coming up with solutions is a more convincing policy than a mere obligation to pay for something that was previously available for free. Table 1 offers a tentative overview of carbon reduction solutions and their possible impact on EU goals. As becomes clear from the table, there is no obvious choice of single or combined technological solutions in an optimal package. There are limits to application and different benefits and costs. A sensible approach would therefore be to develop all solutions, and possibly enhance their benefits and address disadvantages. Regular evaluation seems essential.

Table 1: Confrontation of multiple goals and long-term technological solutions

Goals	Sustainability			Security		Competitiveness	
Objectives Long-term technological solutions	Greenhouse gas reduction	Reduction of air pollution	Other sustainability issues	Dependency on fossil fuels	Supply security	Economic activity[1]	Cost reduction
Energy efficiency	+	+	o	+	+	+	?
Renewable power	+	+	o	+	?	+	-
Biomass	0/+	?	-	+	+	+	-
Carbon capture and	+	?	-	-	o	o	-

[1] Direct increase in economic activity in relevant sectors. Indirect and macroeconomic effects can be negative.

storage							
Nuclear energy	+	+	-	+	?	o	?
Switching to natural gas	+	+	o	-	-	o	?
Electrification	+	+	o	o	+	+	-

Renewables and efficiency are major solutions within a low carbon framework
Concrete choices of solutions and quantified targets make policies easier to digest. However, setting separate obligations for these solutions should be done with care. It is not clear beforehand what the actual costs of separate technologies are and how they will develop over time and in different countries. Therefore, setting weakly founded renewable or efficiency targets for 2030[2] may be a too costly or unfeasible detour on the road to the low carbon solution of 2050.

Uncertainties are large
An extensive scenario analysis has been made to underpin the EU Low Carbon Roadmap (EC 2011c), dealing with varying fossil fuel prices and differences in global action. Moreover, some technological uncertainties regarding CCS and electrification are dealt with. Many technologies are included, and the scenarios do not seem overly optimistic or optimising unrealistically. However, more important uncertainties include barriers for energy efficiency improvement and renewables. Cost estimates for these vary widely and can be substantially higher in practice than assessed in general studies. Moreover, the effect of policies is assumed to be the ability to harvest the full potential, which is why uncertainties in this respect are disregarded. It is impossible to evaluate specific technology penetration from the available data. However, the long-term rate of efficiency improvement over four decades seems optimistic. Therefore, uncertainties are larger than the ranges that are included in the Roadmap. Moreover, these ranges will differ for each individual Member State and are not fit for target setting.

Renewables or efficiency targets may be based on cost estimates from generalised assessments of technology and disregard actual implementation costs. Cost estimates from a socioeconomic point of view can differ substantially from the costs that the end user faces. For example, electric transport is a reduction option that costs well above 500 euro per tonne of CO_2 from a social perspective. But the fiscal incentives are high, and individuals can still be persuaded to buy. On the other hand, efficiency options with negative costs have to be handled with care. There can be convincing arguments why this potential is not harvested and cannot be booked on the social balance sheet. Hidden costs or strong preferences may have been overlooked for these options. Policies to stimulate separate solutions must therefore be primarily targeted at lifting the real market failures.

Avoiding conflicting goals
When stimulating different solutions to reduce carbon emissions, conflicting effects of policies may occur. A well-known example is the notion that for sources under the ETS cap, additional reduction

[2] The scenario calculations are not specific of the share of renewables or energy efficiency improvement in 2030, nor 2050. Only for power generation, a share of 50-55% renewables in 2050 is indicated.

policies are ineffective. Setting a cap needs to be done with inclusion of already envisaged efforts and effects on industrial energy efficiency, renewables and other reduction solutions. This also includes policies to stimulate electricity savings in households and service sectors. Another conflicting issue related to the ETS is the stimulation of efficient decentralised power generation. This will also release pressure under the ETS and lead to more emissions outside the cap. Policies to stimulate renewables and energy efficiency also compete when energy demand reduction worsens the business case for supply options. Interactions will increase when reduction is deepened. They can be avoided if policy targets for separate solutions are set simultaneously with a clear view of the desired future energy system.

Resuming:

- Real costs and barriers for extended renewables and energy efficiency improvement are not well known and can be underestimated.
- Policies and targets aimed at renewables and energy efficiency have to be based on future technical performance and costs. They have to be monitored carefully and adjusted when necessary since overshooting is costly and should be avoided.
- More transparency on the assumptions underlying targets is needed, especially when targets for separate technological solutions in MS are envisaged.
- Regular evaluation of targets on the road to 2050 and a clear framework for adjustments are essential to mitigate uncertainties
- Conflicting goals can and should be avoided.

Policies addressing market failures

Many energy policies can be regarded as addressing market failures. The concept of market failures can be useful to address the barriers to energy transition.

- First, it refers to classical examples as landlord-tenant situations, information asymmetry and natural monopolies with captive consumers. The market does not automatically provide the optimal level of infrastructure and secure supply.
- Second, not including external costs in the price of fossil energy is regarded as a market failure. From literature (IPCC 2007; Tol 2004), the external costs of CO_2 however show wide ranges, and are not suitable for fine-tuning policy targets to correct market failures. Therefore, common policies to compensate for external costs are CO_2 taxation or emission trading, based on political compromises. In many MS external costs may already have been more than counterbalanced by taxation on energy end use and fuels for private cars[3].
- Third, the development disadvantage that more sustainable technologies have compared to incumbent fossil technology is often called a market failure. Stimulating innovation and diffusion is often merely based on the conviction rather than factual information that the fossil technologies are economically inferior. It is not a sound economic argument, as sustainable technologies may well remain more costly when they reach maturity. In this latter case, policies must not overshoot with strong obligations that are economically unsustainable. However, despite the fact that sustainable technologies may simply not be the direct optimal economic

[3] Regulatory taxes on natural gas and electricity for small users in many MS are well above 100 euros per tonne of CO_2. Excise duties on transport fuels reach to up to 500 euro per ton of associated CO2 emissions. The excise level is also motivated by other costs induced by transport.

choice, they can be preferred for valid other reasons. Consumer preferences, or public considerations on other benefits or sustainability principles may prevail.

Market regulation and standards

The EU has a long tradition in creating internal markets and reaping the benefits of trade. For the gas and power market, the policy framework is in place, but the implementation is still incomplete. EU policies on Ecodesign and vehicle standards are an adequate strategy to address market failures of the first kind. Manufacturers of appliances and cars do not pay the energy bill, and public knowledge on rational purchases clearly needs assistance from standards and regulation. As the extra costs of efficient alternatives are low or absent, and their lifetime is less than 15 years, these policies can certainly contribute to the optimal road to 2050. To this end, standards will need maintenance. They have to be checked and tightened on a regular basis. Market failures of the first kind also occur widely in buildings. The average building owner cannot be expected to have an overview of all relevant sustainable technologies. The same applies to building users. Existing buildings form the single largest potential for energy savings. The costs for harvesting this potential, however, vary considerably. The Energy Performance of Buildings Directive (EC 2010b) allows MS to takes this into account in their legislation. Obligations for industrial efficiency and waste heat can also address existing market failures, but a clear assessment of costs and benefits is necessary to avoid overshoot of costs. In the proposed Energy Efficiency Directive (EED) obligations for waste heat recovery, the cost-benefit check offers an important exemption. Studies on the experiences in the Netherlands with high rates of cogeneration (Daniels 2011) show that these cost limitations are quite relevant. Overlaps of the EED with the ETS should be carefully analysed.

Resuming:

- Standards as included in directives on Ecodesign and Energy performance of buildings and Vehicle standards are powerful instruments to overcome market barriers. They have to be updated on a regular basis and checked for their relevance and economic efficiency.

Observations on securing energy supply

The EU has no specified target for energy supply security. There is no ruler to measure it. The subject of supply security covers a diversity of risks in different time frames that each require separate treatment. According to the EU (EC 2007), renewable energy contributes to security of supply by increasing the share of domestically produced energy, diversifying the fuel mix, diversifying the sources of energy imports and increasing the proportion of energy obtained from politically stable regions. In the proposed Energy Efficiency Directive (EC 2011a), energy efficiency is the most cost-effective and fastest way to increase security of supply. This section analyses the relation between low carbon development and energy supply security.

Depletion of fossil fuels

The most fundamental risk is the depletion of fossil fuel reserves in the long run. Oil is expected to run out first. Depletion does not have the same urgency as the climate problem though. Gas and coal reserves combined with liquefaction technology can warrant fossil fuel supply far beyond 2050. Renewables and energy efficiency will have to play a large role in the very long run, but maybe this is also true for nuclear technologies. The model calculations of the low carbon roadmap 2050 show

that Europe's dependence on imported fossil fuels will decrease substantially[4]. However, unforeseen supply security issues will almost certainly emerge before 2050.

Geopolitical issues and market imperfections
Important security of supply risks also involve geopolitical issues and market imperfections for fossils fuels. Geopolitical risks have occurred in the oil crises of the 1970s, and have incurred legislation on strategic supplies. The perceived risks are sudden changes in the supply system, incurred by governments or market players, which cause absolute shortages or excessive price hikes. The strategy to cope with both geopolitical risks and market imperfections is diversification of the separate supply categories. Transport, power generation and heat applications have to rely on readily available supply alternatives. For Europe, this involves energy diplomacy aimed at increasing the number of reliable suppliers and supply routes. Technologies include extending the gas grid, marine LNG transport, gas to liquids production, and extraction of unconventional fossil energy reserves. Diversification into non fossil supply and demand side measures is also stated as a strategy for supply security by Member States and the EU. However, flexibility in supply of renewables and flexibility on the demand side is limited. Fossil fuels are most substitutable in power generation, but not in transport fuels, heating of buildings and industrial production. For these categories, non fossil supply options may only contribute to supply security if substantial electrification, hydrogen or biomass supply is realised. Companies such as Shell and BP are currently investigating these new routes. Energy efficiency measures decrease the absolute amount of fossil fuel demand but do not contribute to flexibility once implemented. So non-fossil options in general cannot provide the flexibility for sudden changes in fossil fuel supply for transport and heating in the short and medium term. It is only after a technological transition in the future that the past and current supply security problems for heating and transport may be solved by non-fossil options. New security of supply risks may also occur in future, e.g. in biomass supply and the vulnerability of the larger power interconnection dependency. However, in the power sector, renewables combined with smart grids can really improve flexibility and diversification. Nevertheless, policies that stimulate renewables and energy efficiency are not the most obvious strategy for mid-term security of supply issues.

Uninterrupted deliveries
Short-term supply security issues refer to accidents or conflicts that interrupt direct supply in the gas or power grid. Reserve capacity, additional grid and back-up systems constitute the strategy to cope with these occurrences. There is no argument that specifically supports deep carbon reductions and high levels of modern renewables and energy efficiency as relevant solutions here. Interruptions may occur even more in a low carbon future if energy can be stored to lesser extent than in a fossil world.

According to the Commission's blueprint for an integrated European energy network (EC 2010c) 200 billion euro needs to be invested in transmission networks alone in Europe in the next decade. This

[4] Implicitly, supply insecurity is assumed to be identical with fossil fuel use in the roadmap. This may not be the case in decades to come. According to the impact assessment (EC2011c), the International Energy Agency estimates that by 2035 some 75% of conventional crude oil production will have to come from fields yet to be developed or found. These fields may be located in the US or Japan. Moreover, countries currently deemed to be a geopolitical risk may be reliable partners in 2030.

is substantially more than what the European transmission system operators currently have planned. The Commission recognises that substantial financial and institutional barriers exist for grid investments. The blueprint may advance further development of policy instruments to address this potential supply security problem.

In conclusion, deep carbon reduction is not the short road to supply security. Diversification of suppliers and supply routes for fossil fuels is a more obvious strategy. The case for stimulating renewables or energy efficiency up to 2050 for security of supply reasons alone is weak. Supply security involves many other aspects of flexibility in technologies, trading and infrastructure. It is only in the role of ultimate replacement of dwindling fossil fuel supply that renewables and energy efficiency offer strong solutions for supply security. In the low carbon roadmap, the decreased dependence on imported fossil fuels can, however, be a meaningful co-benefit of the deep CO_2 reduction.

Resuming:

- Fossil fuel supply is finite, but is not limiting in the timeframe up to 2050. Addressing depletion of fossil fuels in the very long run is not the most urgent reason to stimulate renewables and energy efficiency.
- Supply security currently can be improved by diversification, but needs well-founded indicators and criteria. Diversification of fuel supply for transport and heating needs to be addressed by increasing the number of reliable suppliers and supply routes. Renewables and energy efficiency play a minor role in this respect.
- Important investments in energy infrastructure are needed to ensure uninterrupted delivery now and in the future. This needs to be addressed on the EU level, but still requires strong policies.

Policies to address external costs: reinforcing the ETS

For investors, the current ETS price of CO_2 lies somewhere between 12 and 15 euro. In their perception this differs substantially from the 30-35 euro in the initial calculations of the 20-20-20 package (EC 2008) launched in January 2007. In May 2010, the Commission explained (EC 2010d) how changed global circumstances have impacted on the targets set in 2008. The economic downturn slowed down energy use and greenhouse gas emissions, lowering the ETS CO_2 price and its pressure to reduce CO_2 emissions. While the absolute costs of meeting a 20% target have been reduced on the one hand, the fact is that the 20% target becomes less effective as a motor for change.

Although criticised, the ETS can still be a powerful strategy for optimal greenhouse gas reduction and energy transition. But it needs to be improved and strengthened. Three lines of improvement are necessary: setting a long-term cap, scope expansion, and reliability.

Setting a long-term cap

According to the ETS directive the cap will decrease each year by 1.74% of the average annual total quantity of allowances issued by the Member States in 2008-2012 (EC 2009a). This annual reduction will continue beyond 2020, but may be subject to revision not later than 2025. In the climate roadmap to 2050, it is acknowledged that this rate is too low. According to the indicative ranges in

the roadmap, the power sector has to reduce 93-99% and industry 83-87% by 2050[5]. In the underlying reduction scenarios, CO_2 prices range from 104 to 370 euro/tonne in 2050 (EC 2011c). From the impact assessment, it is still largely unclear what technological measures are required. It is important to assess the effects on the economic position of the energy sector and energy intensive industry. A reality check is needed on the required amount of efficiency improvement and the share of renewables.
A clear vision of the long-term ETS cap still needs to be developed, including an analysis of its optimality, and the underlying assumption thereof. Within this vision, it is not a sign of weakness to consider future situations where a long-term cap has to be adjusted. Lacking global cooperation, but also technological or scientific breakthroughs may be reasons to adjust the roadmap. Investors understand these uncertainties, but need certainty about the intentions and determination of politicians and predictability of their behaviour. In the reduction scenarios for the low carbon roadmap, some uncertainties are analysed regarding CCS and electrification.

Expanding the sectoral scope
The advantage of the cap and trade system is that it can achieve a fixed target in a cost optimal way. To reduce emissions of sources outside the ETS, achievement of a target is most uncertain, and costs may be higher than needed. Therefore, extending the scope of the ETS to more sectors and more countries would be a logical move on the long road to 2050. The Commission is currently active with aviation and freight transport, but there is no basic objection to eventually including households, small commercial emitters and all road transport. An upstream obligation for distributors of fuels that are to be combusted by customers could be an effective extension of scope in the EU. It could make the Effort Sharing Decision largely obsolete, with a focus on special sources and non CO_2. In addition, it could replace the Energy efficiency obligation schemes in the recently proposed energy efficiency directive (EC 2011a). This would also avoid undesired inefficient overlaps and interactions of the energy efficiency directive with the ETS[6].

Expanding the geographical scope
The Commission is also open for countries outside the EU joining the ETS. Gradual extension and linking up with other systems may be more successful than a worldwide top-down approach. Geographic extension or soft linking with similar systems is indeed essential if a system like the ETS is prolonged up to 2050[7]. Carbon leakage will be the consequence if the geographical scope is not extended. Production outside the EU faces lower marginal costs of CO_2 and may therefore grow at the expense of similar EU production. , Not much carbon leakage is taking place with current low carbon prices. However, unequal competition is an important issue in the distribution of allowances

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[5] 1.74% is defined as a linear rate. A linear rate of 80% reduction in 40 years would imply an annual decrease of 2% of 2008-2010 emissions. With this constant linear rate, the relative rate increases up to 20% annually in the last years before 2050.

[6] E.g. saving household electricity under the EED would not reduce CO_2, but take pressure off the ETS, since the avoided electricity is generated with thermal combustion plants under ETS. The same goes for stimulating small combined heat and power generation outside the ETS. Moreover, all additional savings achieved at plants participating in the ETS would lead to lower CO_2 prices but not to lower CO_2 emission.

[7] Linking should not be focused on cheap offsets leading to “reduction leakage” and taking off pressure from domestic action.

for the third ETS phase from 2013-2020. Many industries have successfully defended their case against buying their allowances on auctions. Free allocation for 2013-2020 depends on energy intensity and the degree of exposure of sectors to competition from outside the EU. This solution for competition, however, does not really address the differences in marginal costs[8]. The only real solution is to apply the same marginal costs of CO_2 to competing production. This needs to be imposed by similar policies as the ETS or can, if necessary, be temporarily enforced through border taxation and rebates. The EU needs a firm policy framework for the competition issue of energy intensive production if the ETS is the essential tool for deep carbon reduction.

Stabilising the ETS

Investors in new technologies such as wind energy and CCS need a perspective on returns from avoided CO_2 emissions. They should not only get certainty for separate projects, but also for investment in production capacity, human capital and innovations. At the current CO_2 price level this perspective is rather bleak. Public subsidies on deployment are inherently uncertain. The economic downturn worsens investor perspectives, both on subsidies and on a rising CO_2 price. In this first decade towards a low carbon economy, stable carbon prices are an important beacon. The Commission might consider taking on the more active role of central authority on the carbon market. It could manage the amounts of auctioned allowances or even actively buy and sell, adjusting for economic or other disruptions. Not just private investors, but also governments benefit from higher and stable carbon prices when deep reduction is pursued. Public spending on subsidies for renewables will be lower, and revenues from carbon auctions are higher.

The trust of both investors and authorities also depends on the reliability of the ETS system. Continuous transparent control on all actors and adequate action on irregularities remain of vital importance. Alternatives for the ETS are proposed regularly, but there are no real arguments that suggest that they should perform better than a reinforced ETS.

Resuming:

- Setting a strong cap for both ETS and non- ETS in coming decades for 2030 and onwards is the essential foundation for investment planning and MS policies. But showing ambition is not enough. This target needs a sound underpinning of 1) what is required in terms of low carbon technologies and efficiency, including costs on sectoral and MS level 2) clear assumptions on economic and global energy market development, including conditions for target adjustment
- The EU should actively seek opportunities to expand the ETS to other sectors, other countries and international industry. It should also prepare for instruments to prevent carbon leakage as a default.
- The EU should pay specific attention to increasing confidence in the ETS and in a stable CO_2 price. Strong management on regulatory compliance and on stabilising the allowance price is required.
- Regular evaluation of the ETS is needed to secure effectiveness and efficiency. Stakeholder consultation could be an integral part of this process.

[8] The allocated amount of allowances for an installation is fixed and its value therefore is no part of marginal production costs. See e.g. (De Bruyn 2010).

Policies addressing innovations

The innovation argument for policies to stimulate renewables, efficiency and CCS is powerful. New technologies need support in early stages of development to make them ready for competition with established technology. The merits of many new technologies in these categories have to be explored to make optimal choices towards 2050. In doing so, many opportunities for new economic activity can be found.

The choice for the best technology and for the optimal level and timing of innovation stimulation is complicated. In the early stages, public R&D funding needs to be carefully designed. In the early deployment phase, learning by doing is an important innovation mechanism. Here, strong EU-wide renewables obligations can be more powerful drivers for innovation than financial incentives. Flexibility in these obligations, as currently included in the Renewable Energy Directive, allow for some optimisation of choices within the time frame up to 2020. However, the road along the learning curve is a long one. Policies aimed at learning by searching and learning by doing have to be carefully balanced (Sagara 2006). Learning by doing is much more costly, but still a necessary element. Obligations for current off-the-shelf technology have to be carefully tuned. Investing too much today in technology that is still inferior may create barriers for improved technology later on. These barriers include not only lost funds and lost capacity opportunities, but also loss of public credibility and acceptance. Future renewable obligations have to be carefully checked against the long-term perspectives of the technologies they were intended for.

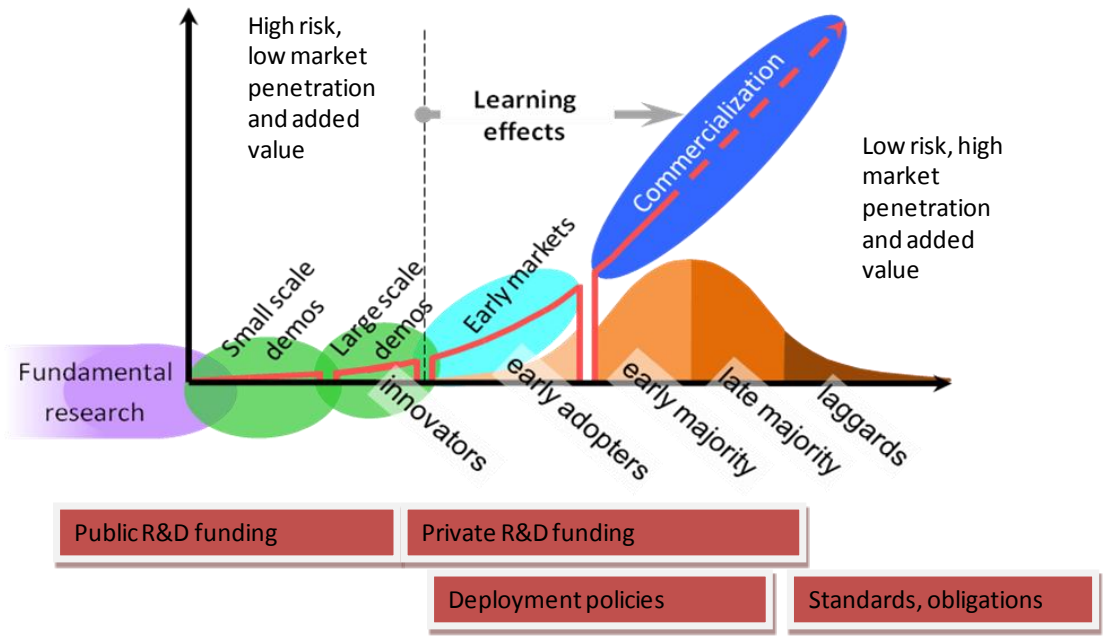

Figure 1: Policies in technology development phases

For energy efficiency, cost reducing innovative technologies are more diverse and less visible than renewable technologies. Innovation can address barriers for energy efficiency improvement in existing buildings and industries. But targets here have to be set with caution and should not be based on bold generic estimates. The proposed energy efficiency obligation schemes in the EED (EC 2011a) for 2020 also offer opportunities for MS to include flexibility and economic efficiency. However, particularly when focusing on buildings, a long- term perspective on deep carbon

reduction of the existing stock is required. Upfront investments for deep reductions are huge. Private owners of buildings are not always experts and need knowledge and confidence to make the right decisions. As the built environment is diverse, transaction costs will be high and a new branch of activities needs to be built up. The obliged parties feel the heat of competition and focus on marginal low risk standardised improvements to achieve 1.5% volume reduction annually. These incremental renovations may well diverge from the structural solutions that are required later on to achieve the targets of the roadmap 2050. Investments in building renovations occur only once in about 20 years and involve large sums including many other non-energy measures. The required energy infrastructure has an even longer life cycle. The choice for distributed heat and power generation is made for many years. A thorough and comprehensive analysis on what Europe's low carbon building stock should look like in 2050 is currently not available. It may show quite different solutions than what obliged parties now focus on.

When aiming innovation policies at cost reductions, there needs to be a clear smart target for the cost reductions that are to be achieved. For energy supply technologies, the SET-plan is clear on targets for deployment and jobs in 2020, but less clear on cost targets in that respect (EC 2009b). Support will have to be continued through the entire development trajectory, customised for its different stages. Sometimes, failures have to be accepted. There are not only positive effects of technological learning, but also diminishing returns on investment when low hanging fruit is picked. This is the case for additional insulation of existing buildings, small-scale biomass options or less attractive locations for wind energy. Innovation policies have to take all that into account to deliver results. A transnational scope for innovation policies may yield larger and more cost effective potentials.

Observations on economic benefits

As the market does not spontaneously deliver sustainable energy solutions, innovation policies are designed to help produce viable business cases. The mechanisms of energy innovation policies are still under scrutiny (Schoots, 2010). While costs and benefits of solutions are frequently evaluated in techno-economic analyses, dynamic effects of innovations on the economy are much harder to identify beforehand. Still, dynamic effects on the economy are very much welcomed by governments. Especially in times of low economic growth, win-win policy options that deliver both economic activity and sustainability are pursued. When production factors like labour are idle, investment in the energy transition may boost economic activity. This is the reasoning behind the Commission's 2009 European Energy Programme for Recovery. However, there are supply constraints on production factors. Labour, capital and intellectual capacity can be allocated to other areas where they are more beneficial. When society loses economic activity because public policies have lead to different choices, then an optimal market would have made.

So how can we make the best of both worlds? How can policies aimed at energy innovation be pointed in the same direction that the market would choose? Should winners be picked or is a generic policy more beneficial? Currently, a mixed approach is adopted in the Netherlands. The initiative lies with private companies under the condition that they make an innovation contract with government and knowledge institutes. The challenge in this innovation contract is to fit private commercial interests into a public frame in which sustainability is one of the conditions. Preferably this should be an international frame, as most major energy companies in the Netherlands are multinationals, and the country is already an important gas, oil, power and biomass hub. The EU is aware of these economic dependencies and could facilitate MS governments to make their own choices to stimulate energy innovation. This would stimulate the internal market and contribute to

the economic and innovation objectives of the EU. Energy technology suppliers in the EU can thus conquer global markets for new energy systems.

Resuming:

- Innovation policies need to be enhanced and made complementary to the functioning of the regulatory frameworks: 1) They require a careful selection of technologies and solutions for deep reductions in the long term; and 2) Once selected, policies to stimulate these technologies require a) smart formulation of milestones and regular monitoring; b) full long-term predictable support, with balanced R&D and deployment.
- Innovation policies require an international scope: MS should be able to make their own choices for innovation to increase benefits towards the European goals.

Observations on dealing with policy uncertainties on the road to 2050

Based on the position of the world leaders in the Copenhagen and Cancun agreements, the greenhouse gas reduction objective of Europe is 80-95% in 2050 compared to 1990. As this reduction is part of a global effort, it only makes sense when the rest of the world takes similar steps. Governments as well as private parties still face uncertainties as to whether this coordinated global effort will take place. Investors will have to decide on large upfront investment, with revenues depending on actual developments of energy and CO_2 costs. Policy makers have to decide on upfront unpopular regulation and increasing financial burdens with long term welfare effects that depend on cooperation of many others. Both governments and private parties will need to build confidence. This confidence can be supported by meaningful indicators of global effort on the long road towards 2050. These indicators deal with capacity building, technology deployment, economics, trade and innovation. Based on these indicators, governments and private parties must be able to adjust their own efforts. These indicators have to include both achieved developments and implemented policies[9]. Implementation of this foreign strategy by the EU could in many ways be more beneficial than a top-down approach of international negotiations on reduction targets.

Improving confidence among investors, consumers and politicians is key for all categories of energy supply and demand. This is the precondition for triggering the large investments needed for energy transition, while at the same time providing a substantial impulse for the European economy. Starting off by setting ambitious goals for 2030 in round figures is not the way to go. Intelligent and well-founded instruments and mechanisms on the appropriate international scale have to be developed first.

[9] Both domains are mutually dependent. Taxation and regulation policies will influence techno-economic properties and their development. On the other hand, the technical and economic properties of available solutions determine their public acceptance. Thus, policies will be more successful when the proposed solutions are acceptable.

Conclusion

Looking at the long-term challenges for Europe's energy future, current policies focusing on 2020 cannot simply be intensified and extrapolated. Ambitious targets for beyond 2020 require robust analysis on barriers and costs and viable technologies and instruments. Only then will the private sectors and consumers invest and move ahead for both sustainability and economic growth. Uncertainties are large and flexibility on an EU level is needed to adapt to global circumstances.

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