Public support to low-carbon innovation: Grants for all?

Sophia Ruester and Luis Olmos

This article is devoted to the financing of innovation activities targeting low-carbon technologies. Its aim is to guide European energy policy makers in the design and implementation of public support policies given the inevitable constraints on funding. We focus on *pre-deployment* innovation, namely research, development and demonstration activities that belong to the early, highly risky stages of the innovation chain and, thus, need direct public support.

The issue

Low-carbon (low-C) technologies, together with complementary flexibility sources such as energy storage or means supporting demand side management, are key in the transition of the European power system towards decarbonization in the 2020/2050 context (see e.g. JRC, 2011; EC, 2011). The majority of possible technologies, however, is not yet competitive or even not technically proven. Substantial additional RD&D activities are required to improve operational characteristics and achieve cost reductions, and, thus, to reach the ambitious target of limiting global warming to a maximum of 2°C above pre-industrial levels and cut emissions by 80% or more for industrialized countries (see also Stern, 2006; Allen et al., 2009; IEA, 2010).

Research intensity in energy is low compared to many other sectors,[1] and in the past was heavily oriented towards nuclear fission and fusion, with very modest amounts spent on other low-C technologies. It collapsed further with the privatization and liberalization of electricity markets. Indeed, it is clearly easier to support risky RD&D under state monopoly ownership as the costs can be passed through to captive consumers. It is also easier to justify charging consumers for RD&D that is directed to reducing the cost of future electricity supply within the country than for RD&D that is directed to support the reduction of global GHG emissions that will primarily benefit the rest of the world.

At present, 70% of non-nuclear energy R&D in the EU are funded privately, and of the 30% that is financed based on public means, the majority actually is provided in a decentralized way by Member States (see EC, 2009). While Member States roughly maintained the real level of RD&D investments spent on non-nuclear energy at around €(2007) 1.5 bn/yr, expenditures in nuclear technologies fell from nearly €(2007) 4 bn in 1985 to less than €(2007) 1 bn in 2007.[2] The financing gap between recent expenditures and those needed to finance innovations in key technologies as identified in the Strategic Energy Technology Plan (SET-Plan) amounts to €47 to 60 billion (EC, 2009). For reasons discussed below it is most unlikely that the current high private share can be sustained at near treble the scale, and additional sources of public funding are required.

[1] Whereas the R&D-to-sales ratio for the energy sector lies with 1.5% clearly below the industrial average of 4.2%, sectors such as the software or health industries show values well above 10% (Jaruzelski et al., 2005).

[2] France, Germany, Italy and the UK accounted for three-quarters of the EU total; different Member States emphasized different clean energy technologies. See also EC (2009b), IZT & Frost and Sullivan (2006), and the IEA Energy Technology R&D Statistics (http://www.iea.org/stats/rd.asp) for detailed information on RD&D investments in low-C technologies.

Do new technologies develop spontaneously?

Does an adequate portfolio of existing and new clean energy technologies develop spontaneously? There are several reasons for doubting this. Reducing CO_2 emissions is a global public good, and unless these reductions are adequately rewarded, or the damaging emissions properly charged, the incentive to develop low-C technologies will be too low. In the absence of any other market failure, a credible and appropriate carbon price should provide sufficient incentives for innovators to invest in RD&D. However, the implemented EU emission trading scheme provides neither a sufficiently high current price nor a credible and adequate future carbon price (see also Aghion et al., 2009).

Even if these problems were overcome, there remain other critical market failures, some of which apply to many forms of private R&D, and some of which are more specific to low-C R&D.[3] These include: (i) the standard problem that without any further support, innovating firms cannot fully appropriate the returns from their research activities due to existing social, market and/or network spillovers; (ii) innovations in clean energy technologies often pair very high capital requirements with substantial economic, technical and regulatory uncertainties, which hampers access to finance; (iii) past R&D and learning economies enjoyed by existing energy technologies make it harder for new technologies to achieve unit cost levels at which they can compete in the market, particularly as companies tend to focus on innovations which are expected to lead to more rapid pay-offs whereas the optimal portfolio has a 2050 (or even longer) time horizon; and, finally, (iv) there is a tension to resolve between the need to encourage private sector R&D, i.e. companies asking for a strong enforcement of intellectual property rights, and the desire to make the resulting discoveries as widely available as possible in developing countries so that they can be deployed at scale.

Without further public support, the level and timing of private investments in the development of new clean energy technologies will be socially suboptimal. These market failures encourage private inventors and investors to focus on projects that pay off in the near term, whereas the optimal portfolio has a considerably longer time horizon – certainly looking ahead to the 2050 target. While the potential market for low-C energy is huge, the margins to be earned, even with an adequate carbon price, will likely be modest, as energy prices are limited by existing well-developed fossil options. Consequently, public support will be far more important than for other types of R&D, such as in the pharmaceuticals sector, that meets new needs or creates products for which there are no close substitutes.

Supporting clean technology innovation: Grants for all?

There are two general types of public support tools available – market pull and technology push instruments. Debates about whether the level, timing and direction of technological change are predominantly influenced by changes in market demand or by advances in technology are ongoing since more than 50 years (see e.g. Nemet, 2009).[4]

---

[3] Jaffe (1996) gives an excellent account of various market and technological spillovers arising from private innovation activities. Martin and Scott (2000) and Foxon (2003) discuss market failures of low-C innovation. For an overview on theoretical analyses of the effects of environmental policy on technological change see Jaffe et al. (2002). For a detailed discussion on the funding gap in the financing of R&D and innovation originating in imperfections of financial markets see Hall and Lerner (2009).

[4] Grubb et al. (2002) and Grubb (2004) provide an interesting comparison of these two polar technological change perspectives in the context of energy and climate policy, discussing in-depth also the respective economic and policy implications.

Market pull instruments trigger market-led technological change and deployment; market signals can indicate the potential need for new technologies and ideally should incentivize researchers and investors to re-direct their resources to promising new technologies in order to keep (or get) a competitive advantage. Measures include regulatory limitations such as GHG emission caps, standard setting, intellectual property protection, or a smart energy market design. However, these measures mainly stimulate innovation through (actual and expectations of) deployment and the presence of the various market failures discussed above probably would lead to sub-optimal RD&D expenditures in the absence of further direct public support measures. There is a consensus in energy technology policy literature that market pull alone typically does not lead to the desired outcomes and that instead both types of policy measures are necessary (see e.g. Norberg-Bohm, 1999; Horbach, 2007; Nemet, 2009).

Hence, the transition to a low-C and at the same time still high-reliability power system, conducted at minimal social cost, will involve the use of technology push instruments, i.e. direct public support to innovation. Thereby, subsidies in the form of grants and contracts are by far the preferred policy instruments to fund clean energy innovation of any type. A prominent example could be the award of € 1 bn to 6 CCS demonstration projects. It could have been a good idea. However, CCS in the power sector is far from becoming a mature and economic technology since many other barriers to its implementation could not be removed (see also Hirschhausen et al., 2010). However, there are also other ways to support RD&D such as equity investments through the European Investment Fund, technology prizes, or investment tax credits (see Box 1).

Box 1: Good practice of alternative forms of public support

The European Investment Fund (owned by the European Investment Bank) uses own funds, funds made available by the EIB, the EC, EU Member States, as well as by other third parties to provide financing support to SMEs. A large part of this support is not provided in the form of subsidies, but indirectly through intermediaries such as venture capital funds or banks. An example for support targeting low-C technology development is the Capricorn Cleantech Fund, a pan-European, early-stage fund based in Belgium, which invests in equity stakes of between 4 and 6 mn € in technology-based SMEs which develop clean technologies (e.g. support to SBAE Algae Company conducting RD&D targeting innovation in biofuel materials).

Another example are technology prizes, which are a quite prominent tool in the US. The US Department of Energy has established a series of hydrogen-RD&D related technology prizes covering several categories including production, storage, distribution and prototypes. Prizes are also focused on the development of other technologies, e.g. a car that reaches 100 miles per gallon ($ 10mn, provided by a private US foundation), a long-lasting light bulb being also more energy efficient than conventional ones ($ 10mn, DOE), or a fuel efficient aircraft ($ 1.6 mn, NASA).

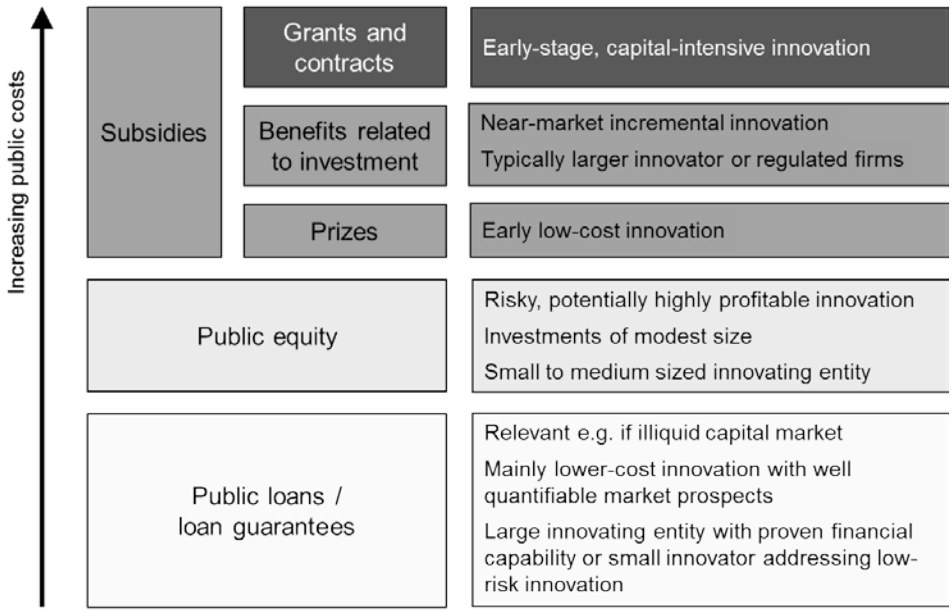
Investment tax credits are an interesting form of public support, too. For instance, the US Storage Technology of Renewable and Green Energy (STORAGE) Act of 2009 recently has extended investment tax credits to electricity storage.

THINK (2011) provides an in-depth analysis on how appropriate financing policy instruments should be chosen. Public money needs to be spent wisely. The form of direct support needs to be tailored to the features of the innovation project (which in turn depend on the respective technology and the level of technological maturity). Relevant features include namely (a) the size of financing gap, (b) the need to target a specific innovation, (c) the probability that funds need to be redirected to alternative innovation projects, and finally (d) the type of innovating entity.

There are **three general types of policy instruments** that can directly mobilize public funds to support innovation: public loans/guarantees, public equity, and subsidies. The public cost of subsidies is higher than that of public loans and equity investments. Loans are paid back with a high probability together with the agreed interest rate. Equity investments allow the public sector to profit from successful innovation.

- Public loans are well suited to finance innovation expected to be profitable, with well quantifiable future market prospects, carried out by large companies. Public loans should replace private loans if the liquidity of the capital market is too low; the innovation targeted is related to activities where the public sector is more experienced; or required investments are too large and risky for any single potential private lender.
- Publicly owned equity is suitable to finance risky innovation undertaken by small entities, or a project company, if the expected net profits of this innovation are positive and any of the following conditions are met: the private equity market is not developed or liquid enough; the public sector has better knowledge about the concerned field than the private one; investments required are too large for a single private equity investor.
- With respect to subsidies, we further distinguish between technology prizes, benefits related to undertaking RD&D investments and grants/contracts. Subsidies in the form of technology prizes shall fund early-stage, low-cost innovation preferably undertaken by universities and research institutes. They have the big advantages of mobilizing private funding, linking the provision of public funds to the achievement of technological targets, and supporting the creation of research networks, since technical objectives typically need to be achieved as fast as possible. Tax credits and other benefits related to RD&D investments are best suited to support near-to-the-market, incremental innovation conducted by large companies. Finally, grants and contracts – on the one hand the most attractive form of support from the innovator's perspective but on the other the most expensive instrument – should only be awarded to socially desirable clean energy innovation that would not be undertaken otherwise and where all other instruments would fail. This is clearly the case for most early-stage, capital-intensive processes as well as for many other pre-deployment RD&D activities.

Figure 1: Alternative forms of public support to innovation



Source: Own depiction

The decision about which projects to support should be based on one single evaluation criterion, namely the expected overall reduction of CO_2 emissions per € of support provided. Thereby, the evaluation of projects addressing more mature technologies can take place through detailed quantitative cost-benefit-analyses. On the other hand, innovation projects addressing highly immature technologies mainly create options. So, very high predicted saving potential in the case of a successful innovation can support the acceptance of very low success probabilities and/or delays in reaching technological milestones. In any case, a ranking of highly immature technologies according to their CO_2 saving potential and probability of success should guide the choice of the technologies to support. As the probability of success increases, funds should be more concentrated and competition among alternative research paths becomes less relevant.

Spending public money wisely also involves designing the application of the chosen financing policy instruments such that they encourage efficiency while not discouraging private sector participation. This implies that competition for funds should be implemented whenever possible to set incentives for high efficiency and minimize public intervention; the public sector should avoid picking winners and instead leave this decision to the industry. Furthermore, public funding should be output-driven whenever this is compatible with the engagement of private innovators. And finally, the institutions set up to allocate funds to clean energy RD&D should be lean and flexible enough to avoid institutional inertia and lock-in, which make it hard to reallocate funds when it becomes clear that the original projects turned out to be less promising than expected.

Need for EU involvement?

Is there a need for joint action at a supra-national level? Alternative forms of EU involvement in energy policy have been addressed by THINK (2011b and 2012). They are based on the implicit understanding that the move of regulatory power from a lower to a higher federal level, i.e. from national to trans-national or even the European level, has benefits and costs: benefits may result in the convergence of national policies and, thus, to overall economic benefits that can be shared; transnational externalities can be internalized and thus treated more efficiently, and network benefits be reaped that might not have been realized by national policies. Potential disadvantages (and thus arguments favoring national approaches) are the disregard of national specifics, the reduction of institutional competition between alternative policy approaches, and the loss of decentralized "participatory energy".

The challenges we face, i.e. those accompanying the transition to a low-C, high-reliability power system at acceptable social costs, are clearly European and individual Member State action is likely to lead to a sub-optimal outcome. Although the EU's contribution to energy RD&D is modest, it can play a number of important roles. In particular, EU funding can encourage a coordinated increase in Member State's research in promising areas; support high risk, high cost, long-term programs that would be challenging even for the larger Member States; encourage cross-border partnerships to transfer skills from stronger to weaker partners; play a strategic role in rebalancing the portfolio of projects to offset any tendency that Member States might have to concentrate on a subset of more immediately prospective innovations; encourage the wider dissemination of RD&D; and, finally, may create a more credible future funding environment by requiring joint agreements that take precedence over domestic funding allocations.

Financial support to RD&D takes place both in a decentralized manner on a Member State level as well as via a centralized distribution of EU and pooled Member State funds.

However, support programs are hardly coordinated – neither between different Member States, nor between them and the EU. This restricts knowledge sharing, increases the likelihood of costly duplication of similar research and fails to exploit potential benefits from economies of scale and scope via a pooling of resources and active networking. Therefore, **coordination** among Member State and EU support policies has to be improved. Public support should focus on a balanced portfolio of identified key technologies. An *updated SET-Plan, considering also the post-2020 timeframe* with intermediate milestones for 2020, 2030 and 2040, could be the right frame.

In addition, we highly recommend enhancing the **cooperation** vis-à-vis research activities, the sourcing of funds and (co-)funding initiatives. Cooperation among Member States is preferable whenever the common interest is larger than the sum of the individual states' interests (Lévêque et al., 2010). It is also useful to avoid duplication of research. The initiation of *European Energy Research Alliances* – aimed at conducting pan-European RD&D by pooling and integrating activities and resources, building on complementarities and synergies, and combining national and EU sources – is a step into the right direction. Their successful implementation should be fostered and progress monitored. For projects whose returns are subject to very high uncertainty, and which involve large investments, such 'joint programming' is highly recommended.

References

Aghion, P., R. Veugelers, and C. Serre (2009): Cold Start for the green Innovation Machine. *Bruegel Policy Contribution*, Issue 2009/12.

Allen, M., D. Frame, C. Huntingford, C.D. Jones, J.A. Lowe, M. Meinshausen, and N. Meinshausen, (2009): Greenhouse-gas emission targets for limiting global warming to 2oC. Nature, Vol. 458, pp. 1163-1166.

EC (2009): Accompanying document to the SET-Plan – Impact Assessment. SEC(2009) 1297.

EC (2009b): Accompanying document to the SET-Plan – R&D Investment in the Priority Technologies of the SET-Plan. SEC(2009) 1296.

EC (2011): Energy Roadmap 2050. COM(2011) 885/2.

Foxon, T.J. (2003): Inducing Innovation for a Low-Carbon Future: Drivers, Barriers and Policies. Report for The Carbon Trust.

Grubb, M. (2004): Technology innovation and climate change policy: An overview of issues and options. *Keio Economic Studies*, Vol. 41, No. 2, pp. 103-32.

Grubb, M., J. Koehler, and D. Anderson (2002): Induced technical change in energy/environmental modelling: Analytic approaches and policy implications. *Annual Review of Energy and the Environment*, Vol. 27, pp. 271-308.

Hall, B.H. and J. Lerner (2009): The Financing of R&D and Innovation. NBER Working Paper 15325.

Hirschhausen, C.v., C. Haftendorn, J. Herold, F. Holz, A. Neumann, and S. Ruester (2010): Europe’s coal supply security: Obstacles to carbon capture, transport and storage. CEPS Policy Brief 223/November 2010.

Horbach, J. (2007): Determinants of environmental innovation—new evidence from German panel data sources. *Research Policy*, Vol. 37, No. 1, pp. 163-73.

IEA, (2010): World Energy Outlook 2010. IEA/OECD, Paris.

IZT & Frost and Sullivan (2006): Portfolio Analysis of European Community non Nuclear Energy RTD Projects in their overall EU Context. Final Report.

Jaffe, A.B. (1996): The importance of spillovers in the policy mission of the Advanced Technology Program. *Journal of Technology Transfer*, Vol. 23, No. 2, pp. 11-19.

Jaffe, A.B., R.G. Newell, and R.N. Stavins (2002): Environmental Policy and Technological Change. *Environmental and Resource Economics*, Vol. 22, No. 1, pp. 41-69.

Jaruzelski, B., K. Dehoff, and R. Bordia (2005): The Booz Allen Hamilton Global Innovation 1000: Money Isn’t Everything.

Joint Research Center (2011): 2011 Technology Map of the SET Plan – Technology descriptions.

Jones, C. and J.-M. Glachant (2010): Towards a Zero Carbon Energy Policy in Europe: Defining a Feasible and Viable Solution. MIT CEEPR Working Paper 2010-002; also published as EUI Working Paper, RSCAS 2010/17.

Lévêque, F., J.-M. Glachant, J. Barquín, C.v. Hirschhausen, F. Holz, and W.J. Nuttall (2010): Security of Energy Supply in Europe – Natural Gas, Nuclear and Hydrogen. Loyola de Palacio Series on European Energy Policy, Edward Elgar Publishing.

Martin, S. and J.T. Scott (2000): The Nature of Innovation Market Failure and the Design of Public Support for Private Innovation. *Research Policy*, Vol. 29, No. 4-5, pp. 437-447.

Nemet, G.F. (2009): Demand-pull, technology-push, and government-led incentives fro non-incremental technical change. *Research Policy*, Vol. 38, No. 5, pp. 700-9.

Norberg-Bohm, V. (1999): Stimulating green technological innovation: an analysis of alternative policy mechanisms. *Policy Sciences*, Vol. 32, No. 1, pp. 13-38.

Stern, N. (2006): Stern Review on the Economics of Climate Change.

THINK (2011): Public support for the financing of RD&D activities in new clean energy technologies. Final Report THINK Topic n° 1. Project leader: David Newbery; research team: L. Olmos, S. Ruester, S.J. Liong, J.-M. Glachant.

THINK (2011b): Transition towards a low-carbon energy system by 2050: What role for the EU? Final Report THINK Topic n° 3. Project leader: M. Hafner; research team: L. Meeus, I. Azevedo, C. Marcantonini, J.-M. Glachant.

THINK (2012): EU involvement in electricity and natural gas transmission grid tarification. Final Report THINK Topic n° 6. Project leader: C.v. Hirschhausen; research team: S. Ruester, C. Marcantonini, X. He, J. Egerer, J.-M. Glachant.