INNOVATIONS FOR A LOW-CARBON ECONOMY

- AN OVERVIEW AND ASSESSMENT OF THE EU POLICY LANDSCAPE

An IEEP report for WWF-Sweden

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2. The paper thus seeks to contribute to creating a better understanding of what still needs to be done at the EU level to increase the market penetration of low carbon technologies in a way that is commensurate with our climate policy goals.

3. While R&D is clearly important, in recognition of the fact that many mitigation options already exist but are insufficiently diffused, the focus here is on helping to understand how commercialisation and dissemination can be enhanced.

4. A number of related policy initiatives in relation to innovation, eco-innovation, industrial policy and climate change are underway, making it helpful to take stock of where we are in terms of the EU policy landscape for the deployment of low carbon innovations.

5. Assessing the adequacy of EU policy for the development and deployment of innovations for a low carbon economy requires at least a working definition of innovation, and would also benefit from a definition of a low carbon economy.

6. 'Systems of innovation' has become a central concept in theoretical, empirical and policy related work on innovation, for example in the work of the OECD.

7. The 'systems failure' approach provides a framework for talking about additional reasons for public policy intervention which are difficult to handle within a 'market failure' frame of reference, and offers something in addition in terms of identifying the challenges as well as prescribing the remedies.

8. The overriding 'adequacy test' of the low carbon economy is whether it allows us to stay within an envelope of emissions that avoids dangerous anthropogenic climate change.

9. Ecological modernisation will not be sufficient and structural solutions will be indispensable; eco-innovations will need to be supported by transition management (or ecological structural policy) in order to secure long term sustainability.

10. 'Power-based' resistance may be countered by conflict resolution strategies addressed at non-innovative polluters. Importantly it would be a strategy based on dialogue.

11. In order to be able to assess the adequacy of EU level action it is also necessary to provide an idea of the boundaries of the EU's competences in relation to those of Member States.

12. In the EU's 'Europe 2020' strategy, economic growth is paramount and innovation is attributed a strategic role in achieving this. Low carbon innovation specifically is also given an important role, both as part of the intention to decouple growth and resource consumption and as a source of growth in its own right. Within that the Innovation Union, Resource

Efficient Europe, and Industrial Policy for the Globalisation Era are the Europe 2020 flagships of greatest significance for the deployment of low carbon innovations.

13. The debate about energy efficiency has to a large extent focussed on efficiency as opposed to absolute reductions. This tends also to be the case in the context of debate about the development and deployment of low carbon innovations.

14. The SCP/SIP Action Plan and the EEAP (and successor) have the potential to deliver substantial deployment of low carbon innovation on a product by product basis. A general condition for this will be that minimum performance requirements are sufficiently stringent, are updated at appropriate intervals and are accompanied by appropriate supporting measures such as e.g. transparent benchmarking and technology procurement.

15. Focus on products will not halt the trend towards *more* energy consuming products, with *greater* functionality, resulting in *increasing use*, and therefore increasing energy consumption. This challenge, we suggest, has not really been taken up in a direct way in the flagship Resource Efficient Europe. Nevertheless, it lies at the heart of the problem.

16. There does seem to be some recognition in the Commission that the transition to a low-carbon economy would require transition management, at least implicitly.

17. The DG CLIMA Communication on a roadmap for a low-carbon economy by 2050, the DG ENER roadmap for a low carbon energy system by 2050 as well as the Communication on a European plan for research and innovation and the Communication on industrial policy will be important in setting out the wider strategic context for a transition to a low carbon economy to 2050, and thus the wider context of the policy landscape for the development and deployment of low carbon innovations that we are concerned with here.

18. There is cause for concern that the overall level of ambition in the Europe 2020 flagships will not be sufficient to truly succeed in de-coupling Europe's growth from resource and energy use, thus placing at risk our capacity to secure sufficient reductions in emissions. And so it runs the risk of failing on its own terms.

19. The SET-plan is focussed on a set of specific technologies (including nuclear), and little or no attention is given to services, or the need to reconceptualise business strategies in a broader sectoral perspective.

20. The SET-plan seems to be very much on research and development and thus the supply side of the innovation chain.

21. The Communication dedicated to the financing of the SET-plan specifically excluded deployment, although another Communication specifically addressing this, especially in relation to renewable energy, was promised.
22. The most market 'pull' oriented section of the SET-plan is in the context of international co-operation.

23. Within the EU innovation strategy, the Lead Market Initiative expressly seeks to address the demand side of the innovation chain, and the sectors it addresses include some that are expressly of interest here.

24. It is clear that the Lead Market Initiative has some way to go before it may bear fruit, and also, in relation to the sectors of interest to us, it is not yet clear what it is that the Lead Market Initiative brings in addition to what is already there.

25. The 2009 review of the EU's innovation strategy highlights a number of important issues and draws attention to the importance of regulation (and standardisation) in stimulating markets for innovative products and services in general.

26. The Competitiveness and Innovation framework Programme (CIP) was intended as the main legal basis, grouping all Community actions in the field of eco-innovation and competitiveness. Together with FP7, CIP is one of the main instruments for achieving the Lisbon agenda goals and it is likely to remain at the same importance level in supporting the new Europe 2020 strategy.

27. Measures relating to low carbon innovation are only a sub-set of the various activities going on under the Environmental Technologies Action Plan (ETAP). It appears that the main added value of ETAP is in agenda setting and influencing rather than in very concrete measures. It will be interesting to see whether the review of ETAP will lead to a more comprehensive and ambitious approach and how this will relate to the innovation and industrial strategies under Europe 2020.

28. *Does the ensemble of policies add up to a coherent whole?* The overall picture which is emerging from the analysis is one of an intertwined web of strategies, action plans, programmes and more specific measures, rather than a coherent framework. The Innovation Union Flagship could help to improve on this situation.

29. *Are there some elements missing?* A number of elements are, as we have seen, missing from the EU policy landscape for the deployment of low carbon innovation, although there is an issue about where we draw the boundary around the low carbon innovation policy landscape in relation to wider climate policy.

30. Appendix B gives an overview of the technologies covered by the different policy initiatives referred to in the text. The question of whether these are the right ones goes beyond the scope of the paper here but could, and should, be explored separately.

31. It is clear that EU innovation policy is overwhelmingly concerned with technology and pays relatively little attention to non-technological innovations. This also applies to low carbon innovations. The Innovation Union flagship suggests that this picture could soften in the future.

32. It is clear that, the Lead Market Initiative notwithstanding, the overwhelming emphasis is on supply-side, with much less attention to the formation of markets, or demand side policy. More emphasis appears to be expended on the development of innovations, including low carbon innovations, than on the deployment of innovations.

33. We have given an overview of funding streams in Appendix A. A more fine-grained analysis could be undertaken. Including of *who* has the institutional capital to access such funding and any implications that might have. More attention could also be paid to the private sector side of the financing coin.

34. *Is the array of initiatives sufficient in relation to the scale of the problem?* There are some generic weaknesses in relation to innovation policy in Europe, and some specific ones in relation to low carbon innovation, and there seems to be limited focus so far on policies specifically focussed on deployment.

35. Some of the language in, for example, Europe 2020 reflects the wider challenges of ecological restructuring that flow from the need to make the transition to a low carbon economy. But Europe does not yet have an industrial policy which addresses this sufficiently.

1 INTRODUCTION

The purpose of this paper is to feed into WWF-Sweden's work on assessing the global conditions for the development and dissemination of low carbon technologies. The focus here is to provide an overview and analysis of EU policies in this area. The paper thus seeks to contribute to creating a better understanding of what still needs to be done at the EU level to increase the market penetration of low carbon technologies in a way that is commensurate with our climate policy goals. While research and development (R&D) is clearly important, in recognition of the fact that many mitigation options already exist but are insufficiently diffused, the focus here is on helping to understand how commercialisation and dissemination can be enhanced.

The main data collection for the report was completed in August 2010. Since then a number of policy developments have taken place:

- Innovation Union. Europe 2020 Flagship Communication. 6.10.2010[1]
- An Integrated Industrial Policy for the Globalisation Era. Europe 2020 Flagship Communication. 28.10.2010.[2]
- A ressource efficient Europe. Europe 2020 Flagship Communication. 26.1.2011. [3]
- Energy Efficiency Plan 2011. 8.03.2011.[4]
- A Roadmap for moving to a competitive low carbon economy in 2050.[5]
- Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system. 28.3.2011[6]

We have as far as possible tried to integrate these developments in the text in the appropriate places.

In recognition of the fact that this is a rather long document and that different readers may be interested in different aspects of the paper, here we provide a short reading guide: In Section 2 we briefly scope out the problem at hand, before moving on to Section 3 which on the basis of a selected review of the literature sets out some influential views on how to think about innovation processes (3.1; 3.2), draws some boundaries around what we might mean by a low carbon economy (3.3), and the scope for EU action (3.4). The reader who already feels familiar with these issues can skip straight to Section 4 where we provide an overview of the EU policy landscape for low carbon innovation, paying particular attention to the features of relevant to 'deployment.' Finally in Section 5 we conclude by making a number of observations in relation to the individual features of this landscape (5.1) as well as in relation to the overall picture (5.2) with reference to the evaluative framework summarised in Section 3.5)

[1] CEC (2010) Europe 2020 Flagship Initiative. Innovation Union. COM(2010) 546, Brussels, 6.10.2010.
[2] CEC (2010) An Integrated Industrial Policy for the Globalisation Era Putting Competitiveness and Sustainability at Centre Stage. COM(2010)614, Brussels, 28.10.2010.
[3] CEC (2011) A resource-efficient Europe – Flagship initiative under the Europe 2020 Strategy. COM(2011) 21, Brussels, 26.1.2011.
[4] CEC (2011) Energy Efficiency Plan 2011. COM(2011)109, Brussels, 8.3.2011.
[5] CEC(2011) A Roadmap for moving to a competitive low carbon economy in 2050. COM(2011)112, Brussels, 8.3.2011.
[6] CEC(2011) Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system. COM(2011) 144. Brussels, 28.3.2011.

2 WHAT IS THE PROBLEM?

An increasing number of studies have developed 'roadmaps' to a low carbon future examining the combination and timing of mitigation options. The European Commission itself has several related roadmap exercises underway or scheduled. The various roadmaps make different assumptions about the composition of mitigation options (e.g. on the inclusion of nuclear fission and CCS; the importance of non-technological options). Assumptions differ on the extent to which different (technological) options are ready for implementation and therefore about the point at which different options could and should be applied, and about how long different options should form part of a portfolio of options (e.g. the 'bridging' potential of CCS). Some argue that we can do all that is needed with existing technologies, others say that significant investment in research and development of new technologies, products, services and processes are needed. Authors also disagree on the extent to which the transition to a low carbon – or less elegantly, but more accurately – low GHG society will require a radical transformation of 'the way we live now'. There is however usually agreement that many good solutions already exists which could and should be scaled up, and that government action will be required to make sure that this happens. For countries that form part of the European Union, government action can include action at the Community level as well as action at Member State and regional level. In this report we are mainly concerned with assessing what is being done to enhance the market penetration of existing 'good solutions' at the Community level, to consider whether this is sufficient in light of the challenge ahead, and to propose some ways forward in so far as this is not the case. In this context it will also be important to bear in mind what competences Member States have conferred on the Union, and the way these interact with Member State competences. This will help to set the boundary around what can be done at the Community level of governance.

3 HOW MIGHT WE ASSESS THE ADEQUACY OF EU POLICY?

Assessing the adequacy of EU policy for the development and deployment of innovations for a low carbon economy requires at least a working definition of innovation, and would also benefit from a definition of a low carbon economy. The former because this will allow us to say something about whether Community level public policy intervenes appropriately in the process of innovation and the latter because it will allow us to say something about whether the explicit or inferable level of ambition is likely to be sufficient for the purposes of securing a low carbon economy by 2050.

In this section we will, based on a limited review of relevant literature, develop a set of questions which can be used to assess the adequacy of EU policy for the deployment of low carbon innovations. These questions are set out in summary form in Section 3.5. We will not be able, within the scope of this paper, to address all the issues raised, and so what we are doing here is to a certain extent also scoping out a wider agenda which can be addressed through follow up work.

3.1 WHAT IS INNOVATION?

The first thing to say is that innovation is a social process and as such our understanding of innovation has evolved with our understanding of social processes in general, in this context particularly in economics and in sociology.

The increasing interest in low carbon innovation, spurred by the need to reduce GHG emissions very substantially, grows out of an older concern with innovation as a means to competitiveness, and a more recent concern with ecological modernisation or eco-innovation as a means of reconciling free market capitalist growth based economies, and environmental concerns. Moreover, the emphasis on innovation has contributed to transcending classical policy boundaries between e.g. industrial policy, environmental policy, and science and technology policy.[7]

Scholars and policy makers therefore come at innovation from a range of disciplinary perspectives, and with different empirical concerns.[8] There are thus a number of ways to think about innovation and it is beyond our scope to provide a comprehensive survey of this literature here. For this reason we draw substantially on a limited number of earlier review articles as a key to the literature.[9]

Foxon (2003) usefully outlines the early 20th century origins of innovation theory and key developments from the early 1980s onwards. An early model of innovation was developed by Schumpeter who identified a three stage innovation process consisting of invention (the first practical demonstration of an idea), innovation (the first commercial application of an invention in the market) and diffusion (the spreading of the technology or process throughout the market[10]). Schumpeter was also interested in the 'drivers' of innovation. In his early work he was particularly interested in the 'heroic' entrepreneurs who brought technologies to the market, while in his later work he became more interested in the role of large firms with the resources to conducts extensive R&D and support new technologies in the early stages of their development.[11] While Schumpeter's three stage model is now seen as inadequate, it underlies what is known as the linear model of innovation[12] which describes innovation as a process of "more or less continuous flow through the three stages, from basic research to applied research to technology development and diffusion."[13] The foundations for thinking about the relative importance of the early stages versus later stages of the 'innovation chain' for facilitating innovation, were laid in the early parts of the second half of the 20th century.[14][15] Foxon (2003) observes that most recent theoretical contributions accept the importance of both 'supply push' and 'demand pull' for facilitating innovation. However, from a policy point of view this remains a live issue as is evident from the fact that Community level innovation policy has been criticised for having insufficient focus on demand side measure, and the hailing of the Lead Market Initiative as the "first comprehensive effort at EU level for a coordinated

[7] Lundvall and Borras (2005) Science, technology and innovation policy. In: Fagerberg, J., Mowery, D., Nelson, R. (Eds), Techniical Chnage and Economic Theory. Pinter, London, pp. 349-369.
[8] Among those interested in innovation from a environmental point of view, one might for example begin to distinguish between those who are most interested in innovation and transitions in energy systems, and those who are more broadly interested in eco-innovation.
[9] Foxon, T.J. (2003). Inducing Innovation for a low-carbon future: drivers, barriers and policies. A Report for the Carbon Trust. http://www.carbontrust.co.uk/Publications/pages/publicationdetail.aspx?id=CT-2003-07. Coenen, L. and Díaz López, J. (2010) Comparing systems approaches to innovation and technological change for sustainable and competitive economies: an explorative study into conceptual commonalities, differences and complementarities. *Journal of Cleaner Production* Vol. 18, pp. 1149-1160.
[10] The classical representation of diffusion is in the form of an S-shaped curve, where take-up begins slowly, then takes off, and achieves a period of rapid diffusion, before slowing down as saturation levels are reached (Foxon 2003, p.3).
[11] Foxon (2003, p. 3).
[12] Foxon (2003)
[13] Foxon (2003, p. 4).
[14] Bush V. (1945). Science: The Endless Frontier, Office of Scientific Research and Development, Washington DC
[15] Griliches Z. (1957). Hybrid corn: An Exploration in the Economics of Technological Change, Econometrica 25, 501-522
Schmookler J (1966). Invention and Economic Growth. Harvard University Press, Cambridge MA

demand-side innovation policy approach."[16] The importance of integrating both approaches is also a central part of the argument made by Grubb (2004).[17] A definition of innovation which nicely integrates the importance of both supply push and demand pull is the one provided by Freeman and Soete (1997): innovation is "the process of matching technical possibilities to market opportunities, through activities including experimental development and design, trial production and marketing."[18] This also draws attention to the iterative and interactive nature of innovation characteristic of current thinking about innovation processes.

Foxon is careful to highlight that while our understanding of innovation has improved, it is still incomplete.[19] He follows Ruttan in his 2001 assessment[20] that while a number of models of innovation (i.e. induced, evolutionary and path dependent) can be distinguished in the literature, these are more akin to complementary aspects of a more comprehensive theory than satisfactory conceptualisations of the innovation process in their own right. Foxon points to more recent systems based approaches to understanding innovation, as more satisfactory, though still incomplete, conceptualisations of the innovation process.[21]

3.1.1 SYSTEMS APPROACHES TO INNOVATION

Systems approaches to innovation are also the subject of a more recent review by Coenen and Díaz López (2010) who distinguish three theoretical frameworks which, according to the authors, have been highly influential in thinking about innovation, competitiveness and sustainability: 'sectoral systems of innovation', 'technological innovation systems', and 'socio-technical systems.' The authors very usefully propose an analytical framework which might be used to compare and contrast any conceptual framework for understanding the innovation process in terms of the assumptions made about: system boundaries; actors and networks; institutions; knowledge; dynamics; policy approach.

The defining feature of systems approaches to innovation is that they understand innovation as "an inherently social, interactive leaning process."[22] The process of innovation is "iteratively enacted through networks of social relations, rather than through singular events by isolated individuals or organizations."

Following Edquist (2005)[23] the authors define innovation as "technologically novel or improved material goods, intangible services or ways of producing goods and services." Referring to Foxon and Pearson (2008)[24] and Kuehr (2007)[25] they suggest that cleaner technologies and methods qualify as

[16] CEC (2009) Lead Market Initiative for Europe. Mid-term progress report. Commission Staff Working Document. SEC (2009) 1198 final. Brussels, 9.9.2009.
[17] Grubb, M. (2004) Technology Innovation and Climate Change Policy : An Overview of issues and Options. Keio Economic Studies Vol. 41 (2), 103-132.
[18] Freeman and Soete (1997) referred to by not directly cited in Foxon (2003)
[19] Foxon (2003, p.5
[20] Ruttan, V. W. (2001) Technology, Growth and Development: An Induced Innovation Perspective, Oxford University Press, New York
[21] Coenen, L. and Díaz López, F.J.D, (2010) Comparing systems approaches to innovation and technological change for sustainable and competitive economies: and explorative study into conceptual commonalities, differences and complementarities. *Journal of Cleaner Production* Vol. 18, pp. 1149-1160.
[22] Coenen, L. and Díaz López, F.J.D, (2010, p. 1150).
[23] Edquist, C. (2005) Systems of Innovation. Perspectives and challenges : In: Fagerberg, J., Mowery, D., Nelson, R. (Eds), Technical Change and Economic Theory. Pinter, London, pp. 181-208.
[24] Foxon, T. and Pearson, P. (2008) Overcoming barriers to innovation and diffusion of cleaner technologies: some features of a sustainable innovation policy regime. *Journal of Cleaner Production.* Vol. 16 (1, Suppl. 1), pp. 148-161.

innovation by virtue of the fact that they "imply technological, organisational and institutional changes to the knowledge base of existing production systems."

'Systems of innovation' has become a central concept in theoretical, empirical and policy related work on innovation, for example in the work of the OECD. It refers to either more broadly to 'systems approaches' or more specifically to a body of work concerned with the functions of particular (often national) systems of innovation. Drawing on Markard and Truffer (2008)[26], 'systems of innovation' are defined as "networks of organizations and institutions that develop, diffuse and use innovations."[27]

It is helpful to review briefly the different systems approaches to understanding innovation processes think about system boundaries, actors and networks, institutions, knowledge, the dynamics of innovation systems, and importantly in this context, the role that they attribute to public policy.

Any analysis seeking to understand a given innovation process or set of processes will need to draw '*boundaries'* around the 'system' under examination. Boundaries are drawn in different ways by different authors. Edquist (2005) provides a useful distinction between boundaries drawn on the basis of geography, technological fields, product areas, and 'activities.'[28] This is, as the authors observe, useful to avoid an explosion of possible factors and drivers for innovation, and we could add, barriers. Coenen and Díaz López recognise that any such boundary should not be conceptualised in too rigid a way as every system of innovation will be set within a certain context.[29]

The analytical boundaries drawn around a given 'innovation system' is of interest to us because, while a substantial amount of effort has been dedicated to understanding 'national systems of innovation' in particular by the OECD, less attention appears to have been paid to innovation in the context of multi-level governance such as would be the case in Europe, nor does much systematic attention have been paid to how the Community level of governance might interact with Member States and with sub-national levels. In the EU context, the different policy areas involved will for example be characterised by different types of competencies conferred on them by the Member States.[30]

Another reason why analytical boundaries are important is that different dynamics of innovation may well characterise different 'sectors' for example. Thus Grubb (2004) observes that the way in which the basic principles of innovation play out in practice, varies radically between different sectors. He contrasts the high degree of innovation information technology and pharmaceuticals with the power sector where "the same fundamental technology has dominated for almost a century and private RD&D has fallen sharply with privatisation of energy industries to the point where it is under 0.4% of turnover (Margolis and Kammen, 1999)."[31] The technologies and business models[32] of the power

[25] Kuehr, R. (2007). Environmental Technologies – from misleading interpretations to an operational categorisation & definition. *Journal of Cleaner Production,* Vol. 15 (13-14), 1316-1320.
[26] Markard, J. and Truffer, B. (2008) Technological innovation systems and the multi-level perspective : towards an integrated framework. Research Policy Vol. 37 (4), pp. 596-615.
[27] Coenen, L. and Díaz López, F.J.D, (2010, p. 1150.
[28] Coenen, L. and Díaz López, F.J.D, (2010), p. 1150.
[29] Coenen, L. and Díaz López, F.J.D, (2010), p. 1150.
[30] See Section 3.4.
[31] Grubb, M. (2004) Technology Innovation and Climate Change Policy: An Overview of issues and Options. Keio Economic Studies Vol. 41 (2), 103-132, p. 177.
[32] cf. Integrated Resource Planning; ESCOs; BP's brief re-branding to 'Beyond Petroleum.'

sector and the energy companies more broadly are clearly of great interest from our point of view, but so are the various end use technologies which transform energy supplied into a variety of energy services. These technologies, and the supply chains associated with them, are quite different from those of the power sector. They will most likely sit somewhere between the two extremes highlighted by Grubb. Moreover, many of them, such as lighting, have in recent years been subject to what might come quite close to looking like a strategic low carbon innovation policy at the Community level in e.g. the context of the recently re-cast Eco-design Directive.[33] [34]

Drawing on Edquist (1997)[35] Coenen and Díaz López then move on to consider the '*components*' of the system and the relations between them. 'Components' refer to the kinds of organisations and institutions that populate a given innovation system. Drawing on Liu and Wu (2001)[36] they add a distinction between primary and secondary actors, where primary actors are "those actors that directly perform innovation activities whereas secondary actors affect the behaviour of or interaction between primary actors."[37] Both the 'sectoral systems of innovation' and the 'technological innovation systems' approaches tend to provide a firm-centred analysis, while the scope of the socio-technical systems approach is much wider.[38] While, the three frameworks adopt similar categorisations of the kinds of actors in the system (universities, public authorities, consumers, suppliers, banks, etc.), they depart from different micro-foundations for organisational behaviour: while the 'sectoral systems of innovation' framework and the 'technological innovation systems' framework are more rooted in economics, while the 'socio-technical systems' framework is more rooted in sociology.[39] This also influences the way they conceive of change, or the dynamics of innovation systems which we consider below.

Systems approaches to innovation attribute an important role to '*institutions'* of different kinds. They recognise that "certain patterns of interaction are more pronounced than others because organisational behaviour and strategy is shaped (though not wholly determined) by various laws, rules, norms and routines (i.e. institutions)."[40] According to Coenen and Díaz López some of the common distinctions made between types of institutions in the literature are between 'formal' and 'informal' institutions (Edquist and Johnson, 1997)[41], regulatory, normative, and cultural-cognitive types of institutions (Scott, 1995)[42] and different levels of institutional structures (Hollingworth, 2000).[43]

[33] Directive 2005/32/EC establishing a framework for the setting of ecodesign requirements for energy-using products and amending Council Directive 92/42/EEC and Directives 96/57/EC and 2000/55/EC of the European Parliament and of the Council.
[34] See also Hinnells, M. and Boardman, B. (2008) Market Transformation: Innovation theory and practice. In: Innovation for a Low Carbon Economy. Foxon, T., Kohler, J.K., Oughton, C. (Eds). Edward Elgar, Cheltenham.
[35] Edquist C (1997). System of innovation: Technologies, Institutions and Organisations. Routledge, London/Washington, p. 408
[36] Liu X., White S. (2001). Comparing Innovation Systems: a Framework and Application to China's Transitional Context. Research Policy 30(7), 1091-1114
[37] Coenen, L. and Díaz López, F.J.D, (2010, p. 1150).
[38] Coenen, L. and Díaz López, F.J.D, (2010, p. 1152).
[39] Coenen, L. and Díaz López, F.J.D, (2010, p. 1152)
[40] Coenen, L. and Díaz López, F.J.D, (2010, p. 1150)
[41] Edquist C, Johnson B (1997). Institutions and Organsiations in Systems of innovation. In Edquist C. (Ed) System of innovation: Technologies, Institutions and Organisations. Routledge, London/Washington, pp. 41-63
[42] Scott W.R. (1995). Institutions and Organisations. Sage, Thousands Oaks, CA
[43] Hollingsworth J.R. (2000). Doing Institutional Analysis: Implications for the Study of Innovations. Review of International Political Economy 7, p. 595-644

In a systems approaches to innovation '*knowledge*' is seen as the most strategic resource and learning as the most fundamental resource (Lundvall, 1992; OECD, 1997).[44] Here Coenen and Díaz López distinguish between systems approaches that treat knowledge as a commodity, susceptible to economic exchange (sectors systems of innovation and technological innovations frameworks) and those that pay more attention to knowledge in practice, an ability to act, rather than a good (socio-technical systems).[45]

Of key interest here is of course how different authors conceptualise change, or the '*dynamics'* of the innovation system under study. This is after all the central challenge in a transition to a low carbon economy. However, while all three systems perspectives on innovation offer richer conceptualisations of change than earlier thinking on innovation, they also appear to have quite distinct concerns. Each has something to contribute to our understanding of change (or indeed lack of change within a given innovation system).

The 'sectoral system of innovation' approach sees change in sectoral systems in as mainly incremental and step-wise, the result of the "co-evolutionary processes of their various elements, involving knowledge, technology, actors and institutions."[46] Innovation processes are seen as "often path-dependent and, through increasing returns and irreversibilities, susceptible to lock-in (Malerba, 2004)."[47] The central idea of 'carbon lock-in' draws on this tradition. The 'technological innovation systems' framework is mainly interested in particular emergent technologies that have not yet achieved breakthrough. Drawing mostly on Hekkert *et al.* (2007) this approach is concerned with mapping the "various functions and activities" that take place in a given innovation system. The approach offers a taxonomy of functions: entrepreneurial activities, knowledge development, knowledge diffusion through networks, guidance of search, market formation, resource mobilisation and creation of legitimacy, counteracting resistance to change. The idea of functions can be used to describe and explain shifts in technology-specific innovation systems, but also provide a basis for policy intervention correcting 'weak' functions. Hekkert *et al*. argue that since functions influence each other, a virtuous cycle can be created within an innovation system which in turn can create sufficient momentum for discontinuous change.[48] . The 'socio-technical systems' framework is, while perhaps theoretically speaking the least immediately accessible, the most comprehensive, and the most satisfactory when it comes to fully understanding the scale of the innovation challenge in the context of a transition to a low carbon future. This because the 'socio-technical systems' framework is primarily geared towards analysing technological transitions whereas the two other frameworks outlined have difficulties in doing so because of "their focus on intra-system drivers, interactions and dynamics."[49]That is to say, that the challenge posed by a transition to a low carbon economy is one of an economy wide transition (also crossing national boundaries) whereas a lot of innovation theory and policy has more restricted empirical concerns. Coenen and Díaz López argue that through its distinct use of the niche and regime concepts, the approach has proven a "highly appropriate framework to understand and explain large-scale and discontinuous changes in socio-technical

[44] Lundvall B. (1992). National innovation Systems. Towards a Theory of Innovation and interactive Learning. Pinter Publisher, London, p. 1-2
[45] Coenen, L. and Díaz López, F.J.D, (2010, p. 1154)
[46] Coenen, L. and Díaz López, F.J.D, (2010, p. 1154)
[47] Coenen, L. and Díaz López, F.J.D, (2010, p. 1154)
[48] Coenen and Díaz López (2010, p. 1154-1155).
[49] Coenen and Díaz López (2010, p. 1155).

systems."[50] This touches on a key issue for our assessment of the EU policy landscape for low carbon innovation. Do the elements add up to a policy framework that will result in sufficient *depth* of innovation, commensurate with our climate policy goals?[51]

One of the important contributions of systems approaches to innovation is that the analysis facilitates a more pragmatic *role for public policy*, one that is not only geared towards correcting the classic 'market failures' relating to innovation, but also certain 'systemic failures', some of which are of particular relevance to a transition to a low carbon economy. [52] [53] Coenen and Díaz López cite a number of authors who have made a contribution to the identification and removal of systemic failures.[54] Notwithstanding differences in intellectual tradition and empirical focus, the three different frameworks reviewed by the authors provide what looks very much like a complementary menu of policy interventions. The 'sectoral systems of innovation' perspective is most concerned with analysing the conditions and the behaviour shaping innovation performance in a sector and the firm is seen as the basic unit responsible for innovation.[55] As such public policy is developed to influence the transformation of sectoral systems, the innovation and diffusion processes, and the competitiveness of firms and countries.[56] Benchmarks are developed as indicators of systemic problems within sectors over time or across different regions or countries. The role of the policy maker is as a facilitator engaging problem solving activities within the relevant policy domain. The aim is to strengthen sectoral innovation performance, and while the main target is SMEs. Interaction with non-firm organisations is also identified as important.[57] Policy makers actively monitor and intervene in the sector with specific policies for the creation of knowledge, provision of R&D financing, enabling extensive and effective cooperation and networks, improving IPR regimes, facilitating technology transfer, supporting skill formation and public procurement (Edquist *et al.* 2004).[58] The 'technological innovation systems' literature[59] is of special interest here, as it is particularly interested in explaining how intervention can foster and diffuse emerging (sustainable) technologies. Policy is prescribed to address systemic failures based on an analysis of the key functions and the identification of any weak points. Policy interventions are thus justified with

[50] Coenen and Díaz López (2010, p. 1155).
[51] See also Foxon, T., and Pearson, P., (2008) Overcoming barriers to innovation and diffusion of cleaner technologies : some features of a sustainable innovation policy regime, *Journal of Cleaner Production* Vol. 16S1 S158-S161.
[52] Foxon and Pearson (2008).
[53] Foxon, T. (2003).
[54] Lundvall B., Borras S. (2005). Science, technology and innovation policy. In: Fagerberg J., Mowery D., Nelson R. (Eds.), The Oxford Handbook of Innovation. Oxford University Press, Oxford, pp. 599-631.
Edquist C. (2005). Systems of innovation. Perspectives and challenges. In: Fagerberg J., Mowery D., Nelson R. (Eds.),The Oxford Handbook on Innovation. Oxford University Press, Oxford, pp.181-208.
Mytelka L. K., Smith K. (2002). Policy learning and innovation theory: an interactive and co-evolving process. Research Policy 31 (8-9), p 1467-1479.
Klein Woolthuis R., Lankhuizen M., Gilsing V. (2005).A system failure framework for innovation policy design. Technovation 25 (6), pp. 609-619.
Frantzeskaki N., deHaan H. (2009). Transitions: two steps from theory to policy. Futures 41(9), pp. 593-606.
Chaminade C., Edquist C. (2006). Rationales for public policy intervention from a system of innovation approach: the case of VINNOVA. In: CIRCLE Electronic Working Paper Series. CIRCLE -Center for Innovation, Research and Competence in the Learning Economy, Lund University, Lund, p. 25
[55] Coenen and Díaz López (2010, p. 1155).
[56] Malerba 2002, p. 262, in Coenen and Díaz López (2010, p. 1155).
[57] Coenen and Díaz López (2010, p. 1155)
[58] Coenen and Díaz López (2010, p. 1155).
[59] The new 'technological innovation systems' literature such as Hekkert et al (2007) and Bergek et al. (2008) is more policy oriented than the seminal work of Carlsson and Stankiewicz (1991). Coenen and Díaz López therefore base their comments on the former authors.

reference to a wider set of considerations than is the case in the context of the 'sectoral innovation systems' approach. Interventions are aimed at strengthening 'weak' functions with reference to the 'phase' of the technology life cycle (i.e. emerging, formative, growth). Policy recommendations are developed on the basis of the identification of 'inducement' and 'blocking' mechanisms, and with reference to the 'functions' of an innovation system. There is no one-size-fits-all as technologies and the dynamics of technological change is seen to differ from technology to technology. Policy prescriptions can include R&D funding and subsidies (for resource mobilisations or knowledge creation), demonstration projects (for knowledge creation), setting up of non-product related products and process methods and standards (for market formation), favourable tax regimes, or minimal consumption quotas (for market formation), information campaigns (for counteracting resistance to change).[60] [61]

Although Coenen and Díaz López do not make reference to the work of Michael Grubb, the perspective he puts forward has similarities with the systems of innovation perspective, although he does not make reference to the 'functions' of an innovation system as such, but rather specifies his policy recommendations on the basis of phases of technology development (in the energy sector).

Grubb (2004) offers a six model of the 'innovation chain' in a market economy:

- *Basic research and development;*
- *Technology specific research, development and demonstration;*
- *Market demonstration* of technologies to show potential purchasers and users that the technology works in real-world applications, and tests and demonstrates its performance, viability and potential market;
- *Commercialisation* – either adoption of the technology by established firms, or the establishment of firms based around the technology;
- *Market accumulation* in which the use of technology expands in scale, often through accumulation of niche or protected markets;
- *Diffusion* on a large scale

In keeping with a broad systems perspective, Grubb stresses that this process is not necessarily linear and that there are "constant feedbacks." Moreover, he argues that while each stage will involve technology improvement and cost reduction, the key barriers and driving forces will change across the different stages, with "technology push" elements dominating at early stage research and "market pull" increasingly important as technologies evolve along the chain. Importantly Grubb stresses that while it is possible to set out a generic model of the innovation process in a market economy, the way in which it is articulated in different sectors will be different and that this will have implications for policy design. He stresses the key role of government across the innovation chain, but also that the nature and extent of government involvement will vary greatly along the innovation chain and between sectors. Grubb discusses the different kinds of interventions that governments can engage in depending on the stage of the innovation chain and the nature of the sector. Grubb argues that while classical innovation policy addresses either the "technology push" or the "market pull" end of the innovation chain, and that in some sectors this may be sufficient, for at least some of the sectors that are key to the transition to a low carbon economy, this will not be adequate, most notably in the energy/power and buildings sector. Here, argues Grubb, such policies will not be sufficient to address the "technology valley of death" (Murphy and Edwards 2003) in the middle of

[60] Coenen and Díaz López (2010, p. 1155).
[61] Target groups are more diverse than in the 'sectoral systems of innovation' framework, and includes entrepreneurs, firms, universities, R&D centres, venture investors among others.

the innovation chain. Grubb sets out a helpful classification of policies to help us across the technological valley of death, enabling the large scale diffusion of technologies:

- *Market engagement* programmes move a 'trial technology' from public R&D funding to engagement with the private sector;
- *Strategic deployment* policies build market scale and thereby buy-down the cost of technologies;
- *Barrier removal* aims to establish a 'level playing field' through removal of regulatory and institutional barriers that generally favour incumbent technologies
- *Internalisation* policies operate in different ways across the innovation chain and essentially seek to internalise the environmental damage associated with incumbent technologies, thus improving the economics of the alternatives.

Finally, the scope of the 'socio-technical systems' perspective does, as we have seen some, go somewhat beyond the traditional territory of innovation, competitiveness, industrial and environmental policy domains. At the same time it has provided some influential policy ideas about strategic niche management based on the work of Rene Kemp. The idea here is to set up transition experiments to "enable spaces for learning, institutional adaptation and constituency building"[62] and thus allowing for disruptive innovation that break the lock-in effect. However authors informed by the socio-technical systems perspective also envision other forms of public policy intervention such as the articulation of expectations and visions, network formation, resource allocation, the facilitation of open ended leaning processes, as well as support for technology diffusion (up-scaling).[63] Consistent with the much wider vision of the 'socio-technical systems' framework, a much wider range of actors is also envisioned and can include wider social movements such as those setting the trend on low carbon forms of social organisation. The UK's Transition Towns movement springs to mind.[64] One of the challenges here is that the boundaries between public policy and social movement begin to blur.

In the above, we have outlined some of the key dimensions of systems approaches to understanding innovation processes with reference to how different authors specify the boundaries around the innovation system or systems that they are interested in, the nature of components and relationships that characterise those systems, including the role of institutions, the way in which system and/or technological *change* is understood, and finally the role that is attributed to public policy. In doing so, we have sought to draw attention to the way this relates to the deployment of low carbon innovations, and more broadly, to a transition to a low carbon economy. We now turn more specifically to a brief consideration of some of the 'barriers' to innovation in general and to low carbon innovation.

3.2 'BARRIERS' TO INNOVATION: MARKET AND SYSTEM FAILURES

Foxon (2003) outlines a number of 'barriers' to innovation including some that are of particular interest from the point of view of a transition to a low carbon economy. These include both some classic 'market failures', some more macro-level barriers relating to 'technological and institutional lock-in', as well as what he refers to as some more 'micro-level barriers' which relate to decision making at the level of the firm and the consumer and which includes some of the problems well

[62] Coenen and Díaz López (2010, p. 1156).
[63] Coenen and Díaz López (2010, p. 1156)
[64] http://www.transitionnetwork.org/about

known to the energy efficiency community. In a later paper Foxon and Pearson (2008), drawing on Smith (2000)[65], advocate grounding public policy intervention in the idea of 'system failures'[66] drawing on what Coenen and Díaz López as we have seen refer to as the 'technological innovation systems' framework and which Foxon and Pearson just refer to as the 'innovation systems approach.' On this approach, concrete empirical and comparative analyses of innovation systems should be undertaken to identify systems failures that can be rectified.[67] [68] Foxon and Pearson observe that in many cases the concept of 'system failure' leads to similar or identical policy prescriptions as the idea of 'market failures', but that the crucial difference between the two approaches is that the former does not presume that public policy interventions can recreate ideal market solutions, assumed to have maximum economic efficiency.[69] However, it seems to us that the 'systems failure' approach provides a coherent framework for talking about some additional reasons for public policy intervention which are difficult to handle within a 'market failure' frame of reference, and so that it does in fact offer something in addition in terms, not only of identifying the challenges but also in prescribing the remedies. Below we seek to integrate the different categories of failures and barriers in Foxon (2003) and Foxon and Pearson (2008) in a single list. While we will not be interested in all of these 'failures' the list provide a useful background for understanding the range of government intervention and the extent to which these failures could or should be dealt with at the EU level.

3.2.1 MARKET FAILURES

The problem of appropriating knowledge: the levels of innovation undertaken by private firms will be less than what is socially optimal because of the problem of appropriating the benefits. Once information has been created it is virtually costless to copy (Arrow 1962).[70] This reduces the incentive for the firm to do the R&D in the first place unless it can find a way to appropriate the benefits. The way public policy addresses this problem is through lowering the cost of R&D through funding, and through providing protection of knowledge through patents.

The problem of taking on the risks of innovation: innovation necessarily involves a degree of uncertainty, and the unwillingness or inability of firms to bear the risks associated with the risks involved in innovation reduces the level of innovation below its theoretically optimal level. Risk can be shifted from one actor to another, and in the context of innovation policy, one avenue for public intervention would be to underwrite some of the risk.

[65] Smith K. (2000). Innovation as a systemic phenomenon: rethinking the role of policy. Enterprise & Innovation Management Studies 2000;1(1): p. 73-102

[66] Edquist C. (1994) Technology policy: the interaction between governments and markets. In: Aichholzer G, Schienstock G, editors. Technology policy: towards an integration of social and ecological concerns. Berlin: Walter de Gruyter; 1994.

Edquist C. (2001) Innovation policy - a systemic approach. In: Archibugi D, Lundvall B-A, editors. The globalizing learning economy. Oxford University Press; 2001

Smith K. (2000) Innovation as a systemic phenomenon: rethinking the role of policy. Enterprise & Innovation Management Studies 2000;1 (1): 73-102

[67] Foxon and Pearson (2008, p. S157)

[68] This approach identifies two conditions for public intervention in a market economy: a) a problem must exist (i.e. a situation in which market mechanisms and firms fail to achieve objectives that have been socially defind through a public policy process); and b) and the state and its agencies must have the ability to solve or mitigate the problem effectively (i.e. the issue of potential government and bureaucratic failure must be addressed) (Foxon and Pearson 2008)

[69] Foxon, T., and Pearson, P., (2008, p. S157).

[70] Arrow K. (1962). Economic welfare and the allocation of resources for invention. In: Nelson R, editor. The rate and direction of inventive activity. Princeton University Press; 1962. p. 609-25

The issue of transferring (some of) the inherent risk associated with innovation processes and arising directly from the necessary uncertainties involved is not only relevant to the earlier R&D phase of innovation, but also to other parts of the innovation chain and in particular to traversing the so-called valley of death between the development of an innovation and the commercialization of it.[71] Part of the challenge here, suggest COWI (2009), is that risks are increased at the comercialisation phase but at the same time this is often also the stage where public support ends, giving rise to what they refer to as a particularly difficult risk profile.[72]

In this context it is worth mentioning a recent initiative in the UK which specifically seeks to address the issue of risk. In 2009, the outgoing UK Government set up a commission to investigate the idea of a Green Investment Bank as a way of enabling the UK to finance its climate change obligations over the next four decades. It reported in June 2010 after the change of Government and makes fascinating reading. The Green Bank Investment Commission argued for the establishment of a Green Investment Bank as part of an overall UK Government policy to open up flows of investment by "mitigating and better managing risk (rather than simply increasing rewards to investors)" and proposed a number of products which such a bank should be proposing to the market.[73]

The problem of externalities: in our context, the most important externality is that the social cost of carbon is not integrated into the relevant market price(s). Until a few years ago there was no price on carbon at all, but since then valiant efforts have been made to put a price on carbon through cap and trade schemes, and in the EU context, the EU–ETS. The alternative, or even complementary, measure would be a carbon tax. Capping GHG emissions, creating property rights to them, and creating a market for them, or putting a tax on GHG emissions equivalent to the social cost of carbon, are all measures which would contribute significantly to creating a demand pull for low carbon innovations. It is however clear at present that we are somewhat far from the price of carbon creating sufficient demand pull in its own right. Nevertheless it is however important to remember that at an EU level this is an important part of the puzzle and we will return to this point.

3.2.2 SYSTEM FAILURES

Smith (2000) in Foxon and Pierson (2008)[74] identifies four areas of systemic failure which could provide the rationale for government intervention.

Failures in infrastructure provision and investment: physical infrastructure (e.g. energy and communications) and science-technology infrastructures (e.g. universities, technical institutes and regulatory agencies) are important parts of innovation systems. But their large scale, indivisibility and long time horizons of operation makes it unlikely that they will be sufficiently provided by private investors. This means that there is a case for public support for infrastructure provision of a variety of kinds.

[71] COWI (2009) Bridging the Valley of Death : public support for commercialisation of eco-innovation. Executive Summary. http://ec.europa.eu/environment/enveco/innovation_technology/pdf/exec_summary_bridging_valley.pdf

[72] One of the ways in which public policy can deal with this is through 'innovation procurement policy' (or 'technology procurement'). A policy instrument developed in the context of the Member State (in particular Sweden), this is in fact something which has been tried at the EU level (the Energy+ project, funded through Intelligent Energy Europe).

[73] Green Investment Bank Commission (2010) Unlocking investment to deliver Britain's low carbon future. Green Investment Bank Commission, London, p. xiii.

[74] Foxon, T., and Pearson, P., (2008, p. S157).

Transition failures: existing firms, and especially small ones, are limited in their technological capabilities and horizons. This means they are likely to experience difficulties in responding to changes, in particular change outside the existing expertise of the firm. Such changes can be in technological opportunities or patterns of demand that push the market into new areas of technology, or major shifts in technological regimes or paradigms. Again this means there is a case for public policy intervention to help firms deal with change.

Lock-in failures: 'path-dependence' leads to the 'lock-in' of existing technologies because of 'system' or 'network externalities', combined with the fact that technologies are closely linked to their social and economic environment. There are two important insights which follow from this observation: firstly, that new technologies must 'compete' not only with components of an existing technology, but also with the overall system on which those existing components are embedded. Secondly, on this view, industries and entire socio-economic systems can get 'locked-in' to a particular technological paradigm.[75] The role of public policy is dual: on the one hand that it should foster the alternative (as we have seen in the idea of strategic niche management), and on the other hand it should seek to overcome the barriers created by the prevalence of incumbent technologies or systems.

Institutional failures: Public and private institutions, regulatory systems and the public policy system together create a structuring framework of opportunities and constraints to innovation by firms. They are an important part of the innovation system. The implication is that the performance of such institutions and systems should be monitored and addressed and to the extent that they are creating unnecessary barriers, this would provide a rationale for policy changes or interventions. The systems-failure approach is designed to help policy makers identify where changes to rule-systems could lead to more effective achievement of social objectives without excessive costs or unnecessary bureaucracy. This is based on the recognition that the various rules governing markets are often already designed to promote various types of socially desirable behaviour that go beyond promoting pure economic efficiency.

3.2.3 MICRO-LEVEL BARRIERS TO LOW CARBON INNOVATION

In his 2003 review article, Foxon also turns to 'micro-level barriers' based on the decision-making at the firm and consumer level. These are mostly taken from the energy efficiency literature and include: 'split incentives', 'asymmetric information', 'access to capital', and 'transaction costs.'

3.3 WHAT IS A LOW CARBON ECONOMY?

The principal rationale for the development and deployment of low carbon innovation from an environmental sustainability perspective is the extent to which the ensemble of innovations will secure a transition to a low carbon economy through a combination of the depth of carbon reduction that they offer individually and the extent of their diffusion. In principle, 'low carbon' can of course mean many things, and does mean many things, to different people. However the overriding 'adequacy test' is whether such a low carbon economy allows us to stay within the envelope of emissions that avoids dangerous anthropogenic climate change. The implications for CO_2 emission reductions over the next 40 years that follow from the science as reviewed in the IPCC's Fourth Assessment Report are without a doubt challenging. In evaluating EU policy for the development and

[75] Foxon (2003, p. 28-30) gives a useful and more developed account of 'carbon lock-in' in particular based on the work of Gregory Unruh (2000; 2002) and others.

deployment of low carbon innovation it is necessary to ask whether it all adds up to the required scale of ambition with reference to stated policy goals for 2020 as well as for 2050. It is an appropriate time to be asking this question as a number of Community level 'roadmaps' are in the pipeline such as Communication on a roadmap for a low-carbon economy by 2050 and the Roadmap for a low carbon energy system by 2050 as well as of course the broader Communication on a European plan for research and innovation and the new industrial policy to be drawn up under the industrial policy of Europe 2020 (see below).

In this context it is worth considering more closely a relatively recent article by one of the originators of the idea of ecological modernisation (a concept which is largely synonymous with eco-innovation), Martin Jänicke.[76] In his paper, Jänicke casts his mind back to the coining of the term in the early 1980s and considers what lessons can be drawn. He concludes that ecological modernisation will not be sufficient and structural solutions will be indispensable, eco-innovations will need to be supported by transition management (or ecological structural policy) in order to secure long term sustainability.[77] Jänicke's paper is also interesting because he places ecological modernisation in an EU policy context including the 2005 Lisbon Strategy for Growth and Jobs, a key strategic policy for the EU until the launch of Europe2020 in 2010.

'Ecological modernisation', understood as systematic eco-innovation and its diffusion, was coined in the early 1980s to address the interplay of economy and ecology. The intention was to link the drive for modernisation in developed market economies and the long term requirement for an *ex ante* more environmentally friendly development through innovation in environmental technologies.[78] The concept has been politically highly successful, notably in Germany, but has also worked its way into a central place in the EU policy agenda in the shape of the closely linked ideas of eco-efficiency and eco-efficient innovation. It became part of the EU Lisbon Strategy for Growth and Jobs,[79] and as we shall see it is at the heart of Europe2020. Ecological modernisation may come in the form of incremental improvement (cleaner technologies) or radical innovation (clean technology). Its ecological effectiveness will be a function of its depth and its diffusion.[80] Jänicke notes that it is crucial to understand the mechanisms underlying the diffusion (or lack thereof) of environmental innovations in order to develop a comprehensive strategy for ecological modernisation.[81] In addition to its political success, Jänicke points to two drivers which he suggests may reinforce each other in the future, increasing the already existing dynamics of environmental innovation. These are in particular the trend towards 'smart' regulation, and the growing business risks for polluters in the context of multi-level governance. We will not go into the second driver here as the focus is on understanding the policy landscape. But the point is that there are a number of elements in the business environment of polluting businesses that push them towards eco-innovation and ecological modernisation.[82] Jänicke sets 'smart' environmental regulation against the context of a broader revalorisation of regulation during the 1990s. It is characterised by sophisticated knowledge embedded regulatory instruments.[83] The UK emphasis on evidence based policy would be an

[76] Jänicke, M. (2007) Ecological modernization: new perspectives. Journal of Cleaner Production 16 (2008), pp. 557-565.
[77] Jänicke, M. (2007) Ecological modernization: new perspectives. Journal of Cleaner Production 16 (2008, p. 557).
[78] Jänicke (2007, p. 557).
[79] Jänicke (2007, p. 558).
[80] Jänicke (2007, p. 558).
[81] Jänicke (2007, p. 558).
[82] Jänicke (2007, p. 560-562).
[83] Jänicke (2007, p. 560).

example, and in particular in the context of low carbon innovation, the Market Transformation Programme.[84] Based on earlier work, Jänicke provides an interesting overview of the elements of a 'smart' and innovation-friendly framework of environmental regulation. Jänicke highlights the Japanese « top-runner » approach as an example of an innovation friendly regulation pattern, suggesting that this seems to be the most advanced and sophisticated approach to ecological modernisation so far. Its « demanding, calculable and dialog-oriented policy style and the broad but integrated actor configuration » match Jänicke's 'smart' and innovation friendly framework for environmental regulation. This, Jänicke observes, is especially true for the adopted policy mix that combines tight standards with economic instruments based on the national targets of the Kyoto protocol. Most importantly, to Jänicke, the top-runner approach supports innovation as a process by taking into account the different phases from innovation (supported e.g. by awards) to diffusion both into the national (lead) markets and the international markets. He suggests that the success story of the Toyota Prius hybrid car can, to a large degree, be directly explained with this kind of innovation-oriented regulation. As noted above, we find elements of this approach in the UK idea of market transformation and in various elements of EU legislation such as the Eco-design Directive, and the Energy Performance of Buildings Directive, most likely because of policy learning in the international energy efficiency community. The former is together with the EU emission trading scheme held up, by Jänicke, as EU based examples of smart regulation that combine strict standards with flexible implementation, and together with mandatory feed-in tariffs for renewable energy, examples of innovation-oriented governance instruments that are flexible enough to take investment cycles into account.[85] At a more strategic level it is found in the elements of the EU's 2008 Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan[86] and the 2006 Energy Efficiency Action Plan[87] which we return to below.

In spite of the political success of ecological modernisation, and in spite of important drivers pushing it forward, Jänicke outlines several reasons why it will not be sufficient and why, in order to stay within ecological constraints, there will have to be an evolution in environmental governance going forward. Firstly he notes that while knowledge-based approaches to environmental governance can meet power-based resistance (power always has the privilege not to learn).[88] Secondly, the concept encounters inherent limits where (potentially marketable) technological solutions are not available.[89] Thirdly, he notes that the modernisation approach is in general not appropriate when risk is acute and immediate defensive action is required. Fourthly, he draw attending to a dimension of the oft cited 'rebound effect' that increases in environmental efficiency can often not be considered a sustained solution as they tend to be easily wiped out by subsequent growth processes.[90] This is also referred to as the "dilemma of the N-curve".

On Jänicke's reading, this means that more far-reaching solutions are required. The first of these is the transition from *incremental* to *radical* innovations where environmentally intensive production processes and products are substituted by environmentally neutral ones. Jänicke contrasts efficiency

[84] http://efficient-products.defra.gov.uk/cms/market-transformation-programme/
[85] Jänicke (2007, p. 560).
[86] COM(2008) 397 Final.
[87] COM(2006) 545 Final.
[88] Jänicke (2007, p. 562).
[89] Jänicke given certain "persistent problems" of environmental policy as examples (e.g. urban sprawl, soil erosion, the loss of biodiversity, the final storage of urban waste, and global climate change).
[90] Jänicke (2007, p. 562).

improvements in coal fired power stations (incremental innovation) with the transition to variants of solar energy (radical). He also suggests that there are *borderline* cases where a variety of incremental improvements together achieve radical improvements, giving the example of the zero-energy house. But this will not itself be sufficient. Jänicke argues that *structural* solutions are required and that these will require the development of an 'ecological structural policy' that imposes non-technical solutions in the form of changes in the structure of supply and demand, affecting the structure of industry and individual life-styles (e.g. personal mobility, housing).[91] As Jänicke notes, this would deeply affect established interests and behavioural structures. There is, he suggests, no empirical evidence for carefully targeted industrial restructuring away from environmentally intensive industries. We are in uncharted territory, the essence of innovation, but at a much grander scale. That is not to say that we do not have experience with e.g. industrial restructuring, but not based on an environmental rationale. The time has come, argues Jänicke convincingly, for an *ecological industrial policy.* Such a policy should make the restructuring process socially and economically acceptable, promoting diversification in product types, social cushioning, retraining and conversion of the affected workforce. In other words, the transition to a low carbon economy will need to include not only a strategy for facilitating the entry of new low or now carbon innovations, but also an exit strategy addressing the consequences for those affected by the "creative destruction" of innovation. Jänicke argues that power-based resistance may be countered by conflict strategies targeting the vulnerabilities of non-innovative polluters. Importantly it would be a strategy based on dialog which confronts polluters with questions about their contribution to long-term environmental problems, the related environmental risks, the available options (innovations, diversification, best practice) and the potential government support needed. Jänicke proposes that this could be the basis for strategic sectoral targets, activities and monitoring mechanisms. [92] Some of the elements of this strategy appear to be already in operation, but not in a way which at the moment looks likely to secure the necessary degree of innovation and transformation.

3.4 THE SCOPE OF EU ACTION

In order to be able to assess the adequacy of EU level action it is also necessary to provide an idea of the boundaries of the EU's competences in relation to those of Member States. While this is a potentially wide-ranging and complex issue, it is nevertheless possible to make a few initial observations which can serve to guide our assessment.

The Union's competences have been conferred on it by Member States. The Treaty on the Functioning of the European Union (TFEU), which together with the Treaty on the European Union, make up the Lisbon Treaty, defines the types of Union competences (Art. 2) and the public policy areas to which each type applies (Art. 3-6). Any measures adopted by the EU institutions must be founded on a legal basis in the Treaty.

As we shall see in Section 4, innovation in general and the deployment of low carbon innovation in particular, cross a wide range of areas defined in the treaty. Many of these, such as for example 'research, technological development and space', 'energy', 'environment' and 'economic, social and territorial cohesion' are shared competences. That is to say both the Union and Member States can legislate and adopt legally binding acts, but Member States can do so only in a residual way when the Union has not exercised its competence or has ceased to exercise it. Further more, in relation to

[91] Jänicke (2007, p. 563).
[92] Jänicke (2007, p. 563).

'research, technological development and space', the Union can define and implement programmes but this must be in such a way as to not prevent Member States from exercising their own competence in this area (TFUE, Part One, Title 1, Article 4). The areas that do not fall under shared competence, tend to either not be directly relevant, or are part of what we might call wider framework condition such as for example 'monetary policy for the euro zone countries' which is an exclusive competence of the Union (only the Union legislates and adopts legally binding acts). There are however some exceptions such as for example 'industry' where the Union has competence to 'carry out actions to support, coordinate or supplement' the actions of the Member States (Art. 6), or economic and employment policies where Member States have to coordinate their policies within the Union and adopt guidelines to this end (Art. 5). In addition, competition rules for the internal market could also be of significance in relation to access by renewable energy producers. While the 'internal market' comes under shared competence, the competition rules are the exclusive competence of the Union.

3.5 ASSESSING EU POLICY

Having considered, on the basis of a selective review of relevant literature, the nature of innovation, and what we might mean by a low carbon economy, as well as the limits to Community level action, we are now in a better position to outline a set of issues which together can be used to assess the adequacy EU policy for the deployment of low carbon innovations. As noted in the beginning of this section, while these issues scope out a wider set of questions than we can answer within the scope of the present paper, the do help to inform the overview in Section 4 and to structure the discussion in Section 5.

At the most general level we can ask whether the ensemble of policies add up to a coherent whole, including whether some of the elements contradict each other.

We can also ask, in very general terms, whether there are some elements missing. Boring down a bit further into this, we can ask what sectors, technologies/end-uses, and actors are addresses, and whether these are the 'right' ones. We can also ask whether intervention addresses the 'right' functions (in the innovation system) and whether this is done in a timely manner in respect of the phase of technological development. Is there a sufficient balance between supply and demand related policies, and do policies allow innovations to traverse the valley of death in security? Is there sufficient attention to innovations that are not technological?

A central question is of course whether the whole is sufficient in relation to the scale of the problem (bearing in mind the scope of Community level action).

We can also ask what the working theory of innovation, low carbon innovation, and the transition to a low carbon economy that emerges from what may perhaps sometimes be institutionally disparate policy initiatives, and whether we agree with this. In other words, if the diagnosis is not right, the remedy prescribed is unlikely to be so.

4 OVERVIEW OF THE EU POLICY LANDSCAPE FOR THE DEPLOYMENT OF LOW CARBON INNOVATIONS

In this section we give an overview and assessment of the most important EU policies and programmes for the development and deployment of low-carbon innovations, with an emphasis on measures for deployment.

The EU does have an innovation policy which we consider in Section 4.4, and it does have a plan, the SET-plan (addressed in Section 4.3), which specifically addresses the technology challenges of reaching the Union's mitigation policy goals. While these are clearly important features in the policy landscape that we are concerned with here, they are by no means the only ones that are of potential relevance to the deployment of low carbon innovations. This means that we will have to survey quite a comprehensive and complex array of initiatives crossing a range of Commission Directorate Generals.

To retain a sense of strategic overview, we have adopted a hierarchical approach, starting with policy statements at the highest levels, and working downwards to more specific policy instruments. One of the advantages of this is that the more high level policy statements often bring together and make sense of the collection of more specific policy instruments. Different bundles of initiatives (such as the Energy Efficiency Action Plan) or more specific instruments (such as ETPs) often appear in various higher level policy formulations, resulting in a somewhat complex tapestry. One of the challenges is that addressing climate change is increasingly integrated into a range of policy domains, and so the field is potentially vast. Together this also means that a wide range of different actors are involved in shaping the relevant policy landscape, both formally and informally.

Appendix A gives a one page representation of the various strategies, plans, programmes and financing and their relation to the different stages of the innovation chain. The scope covers all the stages in the innovation chain, but in the text, our focus is as noted, on the deployment of existing 'good solutions.'

4.1 2010: EUROPE 2020

It is appropriate to start with *Europe 2020 A European strategy for smart, sustainable and inclusive growth*[93] for three reasons, firstly because it gives the shape of things to come, secondly it has a significant focus on innovation, and finally because it integrates EU climate policy goals at the highest level. Europe 2020 was put forward by the Commission in March 2010 and later finalised and endorsed by the European Council in June 2010.[94]

Europe 2020 is intended to guide action both at the Union and at the Member State level to 2020. It sets out three overarching priorities intended to be mutually reinforcing:

1. *Smart growth: developing an economy based on knowledge and innovation.*
2. *Sustainable growth: promoting a more resource efficient, greener and more competitive economy.*
3. Inclusive growth: fostering a high-employment economy delivering social and territorial cohesion.

[93] CEC (2010) Europe 2020 A strategy for smart, sustainable and inclusive growth. COM(2010) 2020, Brussels, 3.3.2010.
[94] European Council (2010) Conclusions 17 June 2010.

Two out of three priorities of Europe 2020 are thus of relevance to our concerns (indicated in italics). This is also the case with two out of the five headline targets of the Strategy, all of which are intended to be measurable:

1. 75% of the population aged 20-64 should be employed.
2. *3% of the EU' GDP should be invested in R&D.*
3. *The 20/20/20 climate/energy targets should be met (including an increase to 30% of emissions reduction if the conditions are right).*
4. The share of early school leavers should be under 10% and at least 40% if the younger generation should have a tertiary degree.
5. 20 million less people should be at risk of poverty.

The Strategy contains seven flagship initiatives to catalyse progress under each of the three priority themes. As five of these are either directly or indirectly relevant to the development and deployment of innovations for a low carbon economy all seven are given here:

1. "Innovation Union" to improve framework conditions and access to finance for research and innovation so as to ensure that innovative ideas can be turned into products and services that create growth and jobs.
2. "Youth on the move" to enhance the performance of education systems and to facilitate the entry of young people to the labour market.
3. "A digital agenda for Europe" to speed up the roll-out of high-speed internet and reap the benefits of a digital single market for households and firms.
4. "Resource efficient Europe" to help decouple economic growth from the use of resources, support the shift towards a low carbon economy, increase the use of renewable energy sources, modernise our transport sector and promote energy efficiency.
5. "An industrial policy for the globalisation era" to improve the business environment, notably for SMEs, and to support the development of a strong and sustainable industrial base able to compete globally.
6. "An agenda for new skills and jobs" to modernise labour markets and empower people by developing their of skills throughout the lifecycle with a view to increase labour participation and better match labour supply and demand, including through labour mobility.
7. "European platform against poverty" to ensure social and territorial cohesion such that the benefits of growth and jobs are widely shared and people experiencing poverty and social exclusion are enabled to live in dignity and take an active part in society.

It is clear that the flagships *Innovation Union* and *Resource Efficient Europe* are most directly relevant. However broader industrial policy will of course also be key in setting the framework conditions for the development and deployment of low carbon innovations. In addition, the transition to a low carbon economy raises issue of skills, this is for example in one of the sectors said to have the greatest and most accessible potential: buildings.

Europe 2020 will guide action not only at the EU level, but also at Member State level and puts in place a governance framework to make this happen, this includes National Reform Programmes, regular reporting in relation to the headline targets (translated at the Member State level) and a set of Integrated Guidelines for economic and employment policies now going through the political

process and set to be formally adopted once the European Parliament has given its opinion. Of the ten guidelines, three are most relevant here:

- Guideline 4: Optimising support for R&D and innovation, strengthening the knowledge triangle and unleashing the potential of the digital economy.
- Guideline 5: Improving resource efficiency and reducing greenhouse gases.
- Guideline 6: Improving the business and consumer environment and modernising the industrial base.

4.1.1 EUROPE 2020 FLAGSHIPS: INNOVATION UNION

The flagships in Europe 2020 are organised under each of the three priorities. The Innovation Union is thus intended to contribute to achieving the Smart Growth priority. The aim of the Innovative Union flagship initiative, as described in the Europe 2020 Communication, is to re-focus R&D and innovation policy on the challenges such as climate change, energy and resource efficiency, health and demographic change. As such, every link in the innovation chain should be strengthened "from 'blue sky' research to commercialisation."[95] The flagships distinguish between EU level action and Member State level action, but here we only discuss Community level action.

Europe 2020 outlines five actions to be taken at European level under the Innovation Union Flagship. Of these three are of particular relevance to our concern with deployment of low carbon innovation. Firstly, the Commission will work to "improve the framework conditions to innovation." The actions cited include the creation of the single EU Patent and a specialised Patent Court; modernising the framework of copyright and trademarks; improving access of SMEs to Intellectual Property Protection; speeding up the setting of interoperable standards; improving access to capital; making full use of demand side policies such as through public procurement and smart regulation.[96] Secondly, the Commission will also launch 'European Innovation Partnerships' between the EU and national levels to speed up the development and deployment and development of the technologies needed to meet the challenges identified above. Three are indicated in Europe 2020 with more to be developed. Of the three partnerships already specified in the Strategy, the partnership on 'the key enabling technologies to shape Europe's industrial future' is likely to be of most relevance. No closer definition of the partnerships is given in Europe 2020 but the October 2010 Communication dedicated to the Innovation Flagship gives more detail (see below). Thirdly, the Commission will work to strengthen and further develop the role EU instruments to support innovation (e.g. structural funds, rural development funds, R&D framework programme, CIP, SET-plan) including through closer work with the EIB and streamline administrative procedures to facilitate access to funding, particularly for SMEs and to bring in innovative incentive mechanisms linked to the carbon market (for fast movers).[97]

The October 2010 Communication, 'Europe 2020 Flagship Initiative Innovation Union', provided more detail on the Commission's plans for innovation over the next decade.[98] As these are a significant part of the context for low carbon innovation we set out the main points and the relevance to low carbon innovation in some detail below. The Communication sets out five things

[95] CEC, op. cit., p. 9.
[96] CEC, op. cit., p. 10.
[97] CEC, op. cit., p. 11.
[98] CEC (2010) Europe 2020 Flagship Initiative. Innovation Union. COM(2010) 546, Brussels, 6.10.2010.

that EU innovation policy must do: tackle unfavourable framework conditions; avoid fragmentation of effort; focus on innovations that address the major societal challenges identified in Europe 2020; pursue a broad concept of innovation; and involve all actors and all regions in the innovation cycle. It thus substantially echoes the priorities set out in Europe 2020. It does, however, begin to put more flesh on the vision.

Of the seven central sections of the Communication, probably the most directly relevant in the context of this report are the sections on 'getting good ideas to market' and on 'pooling forces to achieve breakthroughs: European Innovation Partnerships.' It is also relevant briefly to reflect on the way in which the Communication conceptualises 'innovation'.

With respect to getting good ideas to market, the Communication declares that, "Europe's entrepreneurs currently face multiple obstacles and adverse framework conditions in getting ideas to market", and that, "[a]t a European level, this chain of obstacles needs to be systematically removed and a single market for innovation created."[99] In order to support this objective, the Communication sets out no less than thirteen commitments grouped under the headings of enhancing access to finance for innovative companies; creating a single innovation market; and promoting openness and capitalising on Europe's creative potential.

Reiterating the gaps in finance, the Commission recalls the achievements of the Risk Sharing Finance Facility under FP7 and the financial instruments of the Competitive and Innovation Framework in addressing these, stating that together they have leveraged investments worth well over twenty times the contribution from the EU budget.[100] It also suggests that as flagged in the Europe 2020 strategy, there may be opportunities to bring in further innovative incentive mechanisms linked to the carbon market, in particular for "fast movers." No further detail is given, but the Communication states that the Commission will further explore the idea. Four actions are set out to address the issue of finance gaps: firstly the Commission will put forward proposals that will allow the EU, by 2014, to put in place financial instruments to attract a major increase in private finance and close the market gaps in investing in research and innovation. This would build on the experience from FP7 and CIP referred to above, and should enable to EU budget to create a major leverage effect. It would in particular address the following gaps: investment in knowledge transfer and start ups; venture capital for fast growing firms expanding on EU and global markets; risk-sharing finance for investments in R&D and innovation projects; and loans for innovative fast growing SMEs and midcaps.[101] The other three actions addressing the issue of financing gaps, address the capacity of venture capital funds to invest freely in the EU; the strengthening of cross- border matching of innovative firms with suitable investors; and a mid-term review of the State aid research and innovation framework to clarify what forms of innovation can be properly supported. In relation to mobilising finance for innovation, it is worth noting that the Communication also dedicates to

[99] CEC, op. cit., p.13.

[100] The Commission gives the following figures in the Communication: "to date, contributions for the RSFF of €430 million from the EU budget and €800 million from the EIB, as risk-sharing partners, have supported over € 18 billion investments (15 times the combined contribution to the RSFF and 42 times the EU budget contribution). The €400 million contribution to the CIP financial instruments up to the end of 2009 has leverage d investments of €9 billion (22 times the budget contribution), benefiting some 68000 SMEs." CEC, op. cit., p.14.

[101] CEC, op. cit., p.14.

attention to the way in which the very substantial funding available under the Union's Cohesion Policy funding instruments, could be mobilised more effectively with respect to innovation.

A number of actions are also addressed to create a single innovation market. The idea here is that the single market is still too fragmented into national market and that this is a break on e.g. attracting innovative investment and businesses, competition for the best innovations, and enabling entrepreneurs to commercialise successful innovations and grow their business rapidly. Three of the five actions under this heading are of particular interest. Firstly, the Communication notes that "[w]hereas most previous EU policy initiatives have focussed on supply-side measures which tried to push innovation, demand-side measures give markets a greater role in "pulling" EU innovation by providing market opportunities." It further notes that "[i]nitial steps have been taken under the Lead Market Initiative but a bolder approach associating the supply and demand side are needed."[102] Observing that smart and ambitious regulation can be a key driver for innovation, particularly when dynamic and market based approaches are used, and that this is particularly important for eco-innovation, the Commission recommends that starting in 2011, the EU and Member States should undertake a screening of the regulatory framework in key areas, starting with those linked to eco-innovation and to the European Innovation Partnerships. The other action which may be of potential interest in the context of the deployment of low carbon innovation, is the recommendation that from 2011, Member States and regions should set aside dedicated budgets for pre-commercial procurements and public procurements of innovative products and services (including those defined in the Innovation Partnerships). The Commission suggests that this should create procurement markets across the EU starting from at least €10 billion a year. Thirdly, the Communication states that an eco-innovation action plan will be presented "by early 2011". At the time of writing, this had not yet been presented (see Section 4.8 on the 2004 Environmental Technology Action Plan).

In line with Europe 2020, the Innovation Union Flagship Communication, picks up the idea of European Innovation Partnerships that should help the Union address some of the major societal challenges facing it, among these climate change and the reduced availability of resources. The Partnerships are billed as testing a new approach to EU research and innovation. The Communication sets out the characteristics of the partnerships.

Firstly, states the Communication, the Partnerships will be challenge-driven, focusing on societal benefits and a rapid modernisation of the associated sectors and markets. It is anticipated that they will go beyond the technology focus of existing instruments, such as Joint Technology Initiatives. Secondly, the Partnerships will act across the whole research and innovation chain. They will bring together the relevant actors at EU, national and regional levels in order to: (i) step up research and development efforts; (ii) coordinate investments in demonstration and pilots; (iii) anticipate and fast-track any necessary regulation and standards; and (iv) mobilise 'demand' in particular through better coordinated public procurement to ensure that any breakthroughs are quickly brought to market. Rather than taking the above steps independently, as is currently the case, the aim of the innovation partnerships will be to design and implement them in parallel to cut lead times. Thirdly, they will streamline, simplify and better coordinate existing instruments and initiatives and complement them with new actions where necessary. They will build upon relevant existing tools and actions and, where this makes sense (e.g. for joint programming, lead markets, joint pre-commercial and

[102] CEC, op. cit., p.15.

commercial procurement schemes, regulatory screening), integrate them into a single coherent policy framework.[103] 2011 will be a test phase for the Partnership approach, with the Commission presenting in June 2011 a Communication formalising the proposals for the partnerships and setting out in detail the governance, financing and implementation arrangements. At the end of the test phase, i.e. by the end of 2011, the Commission will review and evaluate the effectiveness of the Partnership approach, and set out whether and how it intends to take it forward, in particular regarding support in the next Research framework Programme. Several of the examples of possible partnerships given in the Communication are of interest: energy, "smart cities", a sustainable supply of raw materials, water efficiency, "smart mobility" and agricultural productivity and sustainability.[104]

The first observation to make is about the underlying vision of innovation in the Communication is that it is regarded as important: "[p]erhaps the biggest challenge for the EU and its Member States is to adopt a much more strategic approach to innovation. An approach whereby innovation is the overarching policy objective, where we take a medium-to longer-term perspective, where all EU and national/regional policies are closely aligned and mutually reinforcing, and last but not least, where the highest political level sets a strategic agenda, regularly monitors progress and tackles delays."[105]

A second observation is that it makes reference to pursuing a broad concept of innovation, both research-driven innovation and innovation in business models, design, branding and services. It thus seems to incorporate, potentially at least, a wider set of innovations than technological innovations. This is also underscored by the reference to involving all actors and all regions in the innovation cycle, not only major companies but also SMEs, the public sector, the social economy and citizens themselves (social innovation).

Thirdly, there seems to be, at least an effort to think in a more focussed way about linking up the supply side and demand side of innovation policy in a strategic framework to drive change in a way that addresses what the Commission defines as Europe's major societal challenges, for example in respect of a the regulatory framework and European Innovation Partnerships.

Finally, the way in which the Communication elevates innovation almost as an end in itself, an end that, by implication will contribute to the quality of life of Europeans, is of concern. History should teach us, that it is not because it is new, that it is necessarily good. And there are many good solutions, to present and future problems that do not need to be invented. This the Innovation Flagship is of a piece with Europe 2020 as a whole: while it has brought sustainability in general and climate change in particular, to the heart of the European policy agenda, it is within an overwhelmingly growth oriented framework, where innovation is understood to be necessarily for the better. This could in the end swamp the good intentions relating to resource efficiency and climate change.

[103] CEC, op. cit., p.23.

[104] CEC, op. cit., p.26.

[105] CEC, op. cit., p.2.

4.1.2 EUROPE 2020 FLAGSHIPS: RESOURCE EFFICIENT EUROPE

Two flagship initiatives are dedicated to the Sustainable Growth priority: Resource Efficient Europe and An Industrial Policy for the Globalisation Era. The stated aims of the flagship Resource Efficient Europe is to support the shift towards a resource efficient and low-carbon economy that is efficient in the way it uses all resources, and to decouple Europe's economic growth from resource and energy use, reduce CO2 emissions, enhance competitiveness and promote greater energy security. While a Communication on the Flagship was published in January 2011, this did in fact not provide much additional detail. We therefore base the discussion on the description of the flagship in Europe 2020.

It is worth noting the way in which Resource Efficient Europe bundles together a resource efficient and sustainable economy, with a competitive economy. These different dimensions of the new economy must be achieved through "exploiting Europe's leadership in the race to develop new processes and technologies, including green technologies, accelerating the roll out of smart grids, using ICTs, exploiting EU-scale networks and reinforcing the competitiveness of [EU] businesses, particularly in manufacturing and within [...] SMEs, as well as assisting consumers to value resource efficiency"[106] Europe will become resource efficient and decouple growth from resource and energy use through the development and deployment of new processes and technologies, and at the same time, these must serve as a motor of growth by virtue of the market shares they command at home and abroad.

Europe 2020 is as the name suggests focussed on the next ten years. One of the initiatives to be undertaken by the Commission in the context of Resource Efficient Europe will be to develop a vision of the structural and technological changes required to move to a low carbon, resource efficient and climate resilient economy by *2050*. This should allow the EU to meet its emission reduction (and biodiversity) targets. Such a vision could help inform company, entrepreneur and investor expectations of the degree of political commitment and the way in which this might be translated at a sectoral level. As a picture of the future, it could, provided it shows sufficient ambition, help facilitate market confidence in investment opportunities in low carbon processes and technologies. Part of this "vision" emerged during March 2011 in the shape of a 'Roadmap for moving to a competitive low-carbon economy in 2050.' One issue is the real political significance of the Communication. It is positioned as a deliverable under the Europe 2020 Resource Efficiency Flagship. National low carbon roadmaps are called for, if not already developed. A number of next steps are set out, referring to initiatives that were for the most part, if not entirely already under way. The Commission invites the other European institutions, Member States, candidate countries as well as potential candidates, and stakeholders to take the Roadmap into account in the further development of EU, national and regional policies for achieving a low carbon economy by 2050. Thus it seems that a potentially powerful overarching vision has been provided, but it will be up to the other European Institutions, Member States etc. whether they will be taking on board this guidance. Another issue is the technology choices underlying the cost-effective pathways. This calls for discussion.

Another initiative of a strategic nature is the long awaited Energy Efficiency Action Plan. This was also eventually published in March 2011, as the Energy Efficiency Plan 2011. The Communication contains seven central sections: one on the public sector leading by example; three sections based sections on

[106] CEC, op. cit., p. 12.

the building, industry, and transport sectors; a section on financing; a section on consumers; and finally a section on a framework for national efforts. In many ways, some of the most important aspects of the text, and the key to understanding its significance can be found in the introduction (on targets), and in the conclusion (on the development of legislative instruments including the adoption of a proposal encompassing the revision of the energy end-use efficiency and energy services Directive and the combined heat and power Directive). One of the central overarching aspects of the Plan is what it says about targets. In the opening section of the Communication, the Commission declares that the 'leading principle' of the plan is to 'propose stringent binding measures without binding national targets.' The Communication also says that if the planned 2013 review of existing indicative (i.e. voluntary) Member State targets (under the energy end-use efficiency and energy services Directive) suggests that the 20 per cent objective is unlikely to be achieved, the Commission will propose legally binding national targets for 2020. The Communication goes on to say that, as in the case of renewable energy, this would take into account the individual starting points of Member States, their economic performance and early action undertaken in the field. Overall the Communication gives a rather vague and somewhat confusing picture of what is being proposed and on what timescale. There is for example no overview of actions with timetables attached. There are references to legal instruments in various parts of the text, and an ambiguous reference to a revision to the legislative framework for energy efficiency policy. But the reader has to wait until the end of the Communication to learn that the binding measures of the plan will be implemented through 'appropriate legislative instruments, including a legislative proposal encompassing revision of the existing energy end-use efficiency and energy services Directive and the combined heat and power Directive.' Also a little curiously, it is left to a footnote to summarise what will be included in the legislative proposal. Reading back through the document, it becomes clear that the legislative proposal which is scheduled for adoption later this year will contain a number of significant measures which could help act on the demand side on low carbon innovation, here in the context of energy efficiency. We consider the 2006 Energy Efficiency Action Plan in Section 4.5.

In the same heading as the Energy Efficiency Action Plan, the Strategy mentions a "substantial programme in resource efficiency" aimed at sustainable consumption and production patterns and aimed at SMEs and households and making use of structural and other funds to leverage new financing. It is not clear how this would relate to the existing Sustainable Consumption and Production & Sustainable Industrial Policy Action Plan (Section 4.2) and what would be *new*. More broadly on financing, Resource Efficient Europe would involve the mobilisation of EU financial instruments (e.g. rural development, structural funds, R&D framework programme, TENs and EIB) as part of a consistent funding strategy, pulling together EU and national, public and private funding. Again, it is a little difficult to say precisely where this will act on the innovation chain, given the limited detail presently available. To the extent the flagship initiative is successful in mobilising existing funding instruments towards its aim, this could, depending on where in the innovation chain the funding was directed, both enhance supply and demand (and thus deployment) of low carbon processes and technologies. However, it is also true that a significant task in "climate proofing" existing funding instruments remains, and these cannot be said to be uniformly pulling in the right direction at present.[107] In this context two Communications contained in the Commission's work programme for 2010 will specifically consider the way in which the contribution of Cohesion Policy to

[107] Medarova-Bergstrom, K. and Schiellerup, P. (forthcoming) Strategies and Instruments for Climate Proofing the EU Budget. Midterm Report for the European Climate Foundation.

Europe 2020 can be reinforced.[108] They should therefore also offer the potential for thinking about the integration of Cohesion policy goals and Climate policy goals. From a different perspective, a Communication on "Mainstreaming Climate Adaptation and Mitigation in EU policies and climate proofing of financial instruments" also contained in the 2010 work programme, will also offer a venue for such reflection.

A Resource Efficient Europe promises to "enhance a framework for the use of market-based instruments" and gives as examples emission trading, revision of energy taxation, the state-aid framework, and encouraging the wider use of green public procurement. No more detail is given. Clearly this could mean a lot of different things and what would be *new* is uncertain too. The emission trading scheme is already a corner stone in the EU's emission reduction strategy. A stable and sufficiently high price of carbon is key both for giving investors sufficient confidence in investing in the supply of low carbon processes and technologies, and in creating the market by stimulating demand. A revision to the energy taxation Directive has been on the cards for a very long time, and is part of the current Commission work programme. Quite what will become of it politically, is uncertain, however to the extent that the taxation framework integrates some recognition of the differences in carbon intensity, it would mirror the effect of the EU-ETS. The encouragement of green procurement has already found itself into different parts of EU policy, and it is not clear whether its inclusion here suggests that there will be a more concerted push. There is broad agreement that the public sector can play a role in stimulating demand for low carbon processes and products through using its purchasing power. Again, quite what this would mean in terms of the state-aid framework remains to be seen. In the meantime, there is a proposal for a regulation on state aid to the coal industry in the Commission's work programme, and recent reports in the press suggests that the Commission is planning to extent support for the coal industry to 2023. [109]

Several initiatives in relation to the energy sector are brought together. But again, most of these are not new. They include completing the internal energy market and implementing the SET-plan (Section 4.3). The promoting of renewable sources of energy in the single market would be a priority. What this would mean in terms of *new* initiatives, if any, to facilitate the deployment of renewable energy technologies also remains to be seen. The Commission will present an initiative to upgrade Europe's networks "towards a European supergrid, 'smart grids' and interconnections in particular of renewable energy sources to the grid."[110] This will presumably be part of the plans for the new Energy Infrastructure Package due to be presented later this year. Another specifically sectoral initiative is the promise of proposals to modernise and decarbonise the transport sector, "thereby contributing to increased competitiveness." This seems substantially oriented towards road and especially individual road transport in particular electric vehicles and providing the infrastructural preconditions for that. There will be a major European "green" car initiative to promote new technologies including electric and hybrid cars through a mix of research, setting of common standards and developing the necessary infrastructure support. The modernisation and decarbonisation of the transport sector, a large and intractable source of emissions, thus appears to

[108] CEC (2010) Annexes to the Commission Work Programme 2010. Time to act. COM(2010)135 final. Brussels, 31.3.2010.
[109] EU plans 'transition subsidies' for coal sector. EurActiv 24 June 2010. http://www.euractiv.com/en/energy/eu-plans-transition-subsidies-for-coal-sector-news-495546
[110] CEC (2010) Europe 2020 A strategy for smart, sustainable and inclusive growth. COM(2010) 2020, Brussels, 3.3.2010. p. 14.

be significantly identified with improvements to individual road transport. A broader White Paper on the future of transport is scheduled for later this year.

Most of the initiatives in Resource Efficient Europe are of relevance in as much as they will shape the conditions affecting companies, entrepreneurs and investors in terms of the successful penetration of their products. At the same time because all of the flagships in Europe2020, including Resource Efficient Europe, have yet to be elaborated in greater detail, it is difficult to get a handle on precisely how the conditions for the deployments of low carbon innovation will be affected. Nevertheless, from an overall strategic point of view, it is obvious that the flagship Resource Efficient Europe will, if it is successful, help create a demand pull for EU based low carbon innovations within the EU and to promote their commercialisation abroad. Otherwise it will have failed on its own terms. That said, at present, the initiatives outlined under the flagship initiative Resource Efficiency Europe are unlikely to add up in a way that will achieve its stated aims.

4.1.3 EUROPE 2020 FLAGSHIPS: INDUSTRIAL POLICY FOR THE GLOBALISATION ERA

The flagship An Industrial Policy for the Globalisation Era will together with Resource Efficient Europe, contribute to the second priority Sustainable Growth. Europe 2020 recognises that "all sectors are facing the challenges of globalisation and adjusting their production processes and products to a low-carbon economy" and that "the impact of these challenges will differ from sector to sector, some sectors might have to "reinvent" themselves but for others these challenges will present new business opportunities."[111]

Nevertheless, the aim of the industrial policy flagship is not specifically set out in Europe 2020. The flagship, as outlined in the Europe 2020 Communication contains a set of actions at the Community level which are of relevance here. The Commission will draw up an industrial policy intended to "maintain and develop a strong, competitive and diversified industrial base in Europe as well as supporting the transition of manufacturing sectors to greater energy and resource efficiency. The Commission will also promote technologies and production methods that reduce natural resource use, and increase investment in the EU's existing natural assets. This is likely to be more direct relevance here, but details are not given. Finally, the Commission will review regulations to support the transition of service and manufacturing sectors to greater resource efficiency and improve European standard setting to leverage European and international standards for the long-term competitiveness of European industry. Europe 2020 states that this will include promoting the commercialisation and take-up of key enabling technologies, but does not give specifics.

The October 2010 Communication setting out 'An Integrated Industrial Policy for the Globalisation Era – Putting Competitiveness and Sustainability at Centre Stage'[112] bills itself as "a fresh approach to industrial policy that will put the EU economy on a dynamic growth path strengthening EU competitiveness, providing growth and jobs, and enabling the transition to a low-carbon and resource-efficient economy." [113] Part five of the report is dedicated to a new industrial innovation policy, but as the Communication states, the overall approach is set out in the Innovation Union Flagship (see above). Part seven of the Communication is dedicated to promoting industrial modernisation. Here a number of actions are included which are of interest such as measures to help

[111] CEC, op. cit., p. 15.
[112] CEC (2010) An Integrated Industrial Policy for the Globalisation Era Putting Competitiveness and Sustainability at Centre Stage. COM(2010)614, Brussels, 28.10.2010.
[113] CEC, op. cit., p. 4.

manage change in the industrial base. In particular there is an action to develop long-term sectoral industrial strategies and policies needed to assess the transition to a low-carbon, resource and energy-efficient economy. This is also picked up in the March 2011 Communication 'A Roadmap for moving to a competitive low carbon economy in 2050.[114] However no further details are given on the nature of these. There are also other actions in the Industrial Union Flagship of potential interest, but quite a few are not really new, and/or are mentioned elsewhere in the text. Part eight of the Communication sets out a number of sector specific initiatives. This includes a section on energy intensive industries. While recalling that low-carbon production technologies and techniques for energy-intensive material processing industries are being developed through Technology Platforms and Lead Market Initiatives, the Commission suggests that "appropriate framework conditions and further public-private collaboration are needed to ensure the timely deployment and comercialisation of these innovations across energy-intensive sectors."[115] To this end the Commission proposes several actions, including a Sustainable Industry Low Carbon Scheme to co-ordinate framework conditions, funding actions, data collection, and other activities by the EU and Member States to promote the development and uptake of low carbon technologies in coordination with the SET-Plan from 2011 onwards. Again there other more action in part eight of the Communication of relevance here, but they are not necessarily new, and/or are mentioned elsewhere in the text.

4.2 2008: SUSTAINABLE CONSUMPTION AND PRODUCTION & SUSTAINABLE INDUSTRIAL POLICY ACTION PLAN[116]

The 2008 Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan was presented as a strategy to "further sustainable consumption and production and promote [...] sustainable industrial policy."[117] It was intended to complement existing policies on energy use, in particular the 2008 energy and climate package (CARE package). As such the core Action Plan contained a "dynamic framework to improve the energy and environmental performance of products and foster their uptake by consumers." This included a perspective and a set of instruments familiar from the market transformation literature: "setting ambitious standards [...], ensuring that products are improved using a systematic approach to incentives and procurement, and reinforcing information to consumers through a more coherent and simplified labelling framework" so that "demand can underpin this policy." It is thus clear that the SCP/SIP contains a specific concern with the demand side of innovation policy.

The most developed part of the SCP/SIP is that dedicated to "smarter consumption and better products." It built on some significant existing pieces of legislation such as the Ecodesign Directive (which sets environmental performance requirements for energy using products), the Energy Labelling Directive (comparison labels on energy using products), the Energy Star Regulation (endorsement labels on energy using equipment), the Ecolabel Regulation (endorsement labels based on a wider set of environmental parameters). The Action Plan highlighted a number of shortcomings with the existing framework including supporting schemes in Member States on information, incentives and public procurement. Overall, concluded the Commission, "voluntary and regulatory instruments are not sufficiently connected and potential synergies between different instruments are not exploited. Implementation is not sufficiently forward-looking to drive the

[114] CEC(2011) A Roadmap for moving to a competitive low carbon economy in 2050. COM(2011)112, Brussels, 8.3.2011.
[115] CEC (2010), op. cit., p.30
[116] CEC (2008) Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan. COM (2008) 397 final.
[117] P.2

performance of products upwards. Divergent national and regional approaches send conflicting signals to producers, and as a result the full potential of the Internal Market is not realized."[118] Accordingly the policy approach put forward in the SCP/SIP sought to integrate the potential of different policy instruments, to implement them in a dynamic way. This included the following actions:

- Extend the scope of the Directive on the Ecodesign of energy-using products to cover all energy-related products; set minimum requirements for products with significant environmental impacts, focusing on key environmental aspects; provide markets with information on best performing products, through the identification of advanced benchmarks of environmental performance; periodically review minimum requirements and advanced benchmarks to adapt them to technological change and provide businesses with a long-term perspective of future regulatory environment.

- Further develop product labelling under the Energy Labelling Directive and Ecolabel Regulation and, following a review of the Ecodesign Directive in 2012, complement these as appropriate by an Ecodesign Labelling Directive to provide consumers with information about the energy and/or environmental performance of products.

- Use the energy efficiency and environmental criteria under the above schemes to establish a harmonised base for public procurement and incentives provided by the EU and its Member States. This was intended to overcome the current fragmentation of stimuli and incentives in the Internal Market.

- A range of other actions to arrive at smarter consumption. In particular, action with retailers and producers of products to "green" their own activities and supply chains, as well as raising the awareness of consumers at large and increasing their proactive role.[119]

The sections of the Action Plan dedicated to "leaner production" appears less developed that the section specifically on product policy, but this may be because it was essentially intended to support the latter.[120] The Communication noted that while the regulatory framework for production processes is well established at the EU level (including the IPPC and EU-ETS) there is a need to give further impetus to resource efficient and eco-innovative production processes, to reduce dependency on raw materials and encourage optimal resource use and recycling.[121] Action was outlined in relation to 'boosting resource efficiency', 'supporting eco-innovation' and 'enhancing the environmental potential of industry', promoting sectoral approaches in international climate negotiations.' In addition to the main lines of activity described above, the Communication also contained a set of actions to promote global markets for sustainable products. [122]

4.3 2007: THE EUROPEAN STRATEGIC ENERGY TECHNOLOGY PLAN

[118] P.3.
[119] P.4.
[120] P.8.
[121] P.8.
[122] P.10-11.

The 2007 SET-plan[123] was developed in the context of the 20/20/20 targets and more long term vision of 60-80% for 2050[124] adopted by the European Council March 2007 to "strengthen energy research, in particular to accelerate the competitiveness of sustainable energies, notably renewables[125], and low carbon technologies and the further development of energy efficiency technologies."

The SET-plan is grounded in a concern about public and private underinvestment in energy technology research in the Union since the oil price shocks in the 1970s and 1980s and the implications that this might have for the three objectives of and Energy Policy for Europe: increasing the security of supply; ensuring the competitiveness of European economies and the availability of affordable energy; promoting environmental sustainability and combating climate change.[126] In the Communication putting forward the plan, the Commission stressed the need to "use the ambition and the targets of the Energy Policy for Europe to create a new European policy for energy technology.[127] It notes that the Research Framework Programmes and the Competitiveness and Innovation Framework Programme (Section 4.6) are the main tools through which actors across the EU currently work together on technological innovation projects but notes that they should be better used to catalyse the actions of Member States and the private sector, calling for a change in the way these programmes are implemented.[128] It cites existing measures over recent years such as the creation of European Technology Platforms (ETPs)[129], the European Research Area and the Networks of Excellence as providing a foundation for further EU action.

The SET-plan was intended to build on this momentum, by "focussing, strengthening and giving coherence to the overall effort in Europe, with the objective of accelerating innovation in cutting edge European low carbon technologies." To do so it promised to provide new joint strategic planning; more effective implementation; increased resources; new and reinforced approach to international co-operation.[130] In the present context it is perhaps most interesting to look at the three latter points. To improve implementation, the SET-plan put in place three mechanisms: European Industrial Initiatives, the European Energy Research Alliance (EERA), and an action on transition planning. EERA is too early in the innovation chain to be examined in greater detail here,

[123] CEC (2007) A European Strategic Energy Technology Plan. Towards a low carbon future. COM(2007) 723 final. Brussels, 22.11.2007.
[124] The "long term vision" for 2050 was superseded (prior to the Copenhagen COP) in the October 2009 Presidency Conclusions. The objective was increased to 80-95% reductions by 2050 over 1990 levels (in the context of the necessary reductions by developed countries as a group). CEU (2009) Brussels European Council 29/30 October 2009. Presidency Conclusions.
[125] CEU (2007) Brussels European Council 8/9 March 2007. Presidency Conclusions. 7224/1/07 REV 1. Brussels 02.05.2007.
[126] CEU, op. cit., p. 11.
[127] CEC, op. cit., p. 8.
[128] Interestingly ETAP is not mentioned here, or anywhere else, in the SET-plan Communication. The question is how the two plans do and should in the future relate to each other. ETAP is currently under review, and we will return to this below, and so is the broader EU innovation policy. Those two may or may not get merged. It is clearly important to watch how those three policy strands interact going forward.
[129] ETPs were first introduced in the context of the 2002 Communication *Industrial policy in an Enlarged Europe.* ETPs were conceived of as detailed actions on specific technologies likely to undergo major developments in the near future and therefore potentially in need of consistent long-term plans for R&D and of increased dialogue and cooperation among stakeholders (Ecorys 2009, P.43). By December 2007 there were some 34 had been created. Some 10 of these had a connection to ETAP. A much smaller number have connection to low carbon innovation. Individual ETPs are suppposed to develop Strategic Research Agendas (SRAs). These are largely implemented through the Specific Programme of Cooperation of the 7th FP (Ecorys 2009, P. 44). When existing programmes are insufficient in terms of scale and scope some SRA scan be implemented as Joint Technology Initiatives (JTIs).
[130] CEC, op. cit., p. 8-9.

and the action on transition planning is currently being taken forward in the context of the FP7 project ATEsT and is thus not directly relevant here either.[131]

4.3.1 THE SET-PLAN INDUSTRIAL INITIATIVES

The SET-plan put in motion the creation of seven Industrial Initiatives (EIIs) with the aim of strengthening industrial energy research and innovation by mobilising the necessary critical mass of activities and actors. They are to be geared towards measurable objectives such as a reduction in cost or improved performance. They are intended to focus and align the efforts of the Community, Member State and industry, and target sectors for which the barriers, the scale of the investment and risk involved can be better tackled collectively.[132] The implementation will depend on the nature and needs of the sector and technologies. The SET-plan thus envisages that for technologies with a sufficient industrial base across Europe, public-private partnerships may be used, whereas for other technologies prioritised by only a few countries, joint programming might be used by coalitions of interested Member States. Six EII's were envisioned to be launched in 2008: wind, solar, bio-energy, carbon capture and storage, electricity grids, and nuclear fission. The first four were eventually launched in June 2010 on wind, solar, electricity grids and carbon capture and storage. The SET-plan notes that "where appropriate, a combination of 'technology push' and 'market pull' instruments may be used." But it appears that on balance, the EII's, like the SET-plan overall is mainly oriented towards the research and developments end of innovation policy. Thus, while the EII's contain technology roadmaps to 2020, which will include actions to develop the technologies and improve their competitiveness, limited attention is paid to the creation of markets.[133]

The Plan states that existing European Technology Platforms should assist in the preparation phase of the European Industrial Initiatives. European Technology Platforms were first proposed in the context of the 2002 Communication Industrial Policy in and Enlarged Europe.[134] They were proposed as a way of bringing together technological know-how and stakeholders with the aim of producing long-term strategic plans for the research and development of specific technologies with a significant economic and societal impact.[135] While there is scope for ETPs to develop deployment strategies, the emphasis of ETPs appears to be very much on the R&D side.[136] [137] This is why, although some of the ETPs also form part of the 2004 Environmental Technologies Action Plan (ETAP), we do not discuss them further here. It is worth mentioning though, before we take leave of the ETPs, that a group of experts convened by the Commission to examine how the activities and achievements of the current 36 ETPs should evolve in the future, had as one of their conclusions that "the demand side for

131 Analysing transition planning and systemic energy planning tools for the implementation of the energy technology information system (ATEST)
http://cordis.europa.eu/fetch?CALLER=FP7_PROJ_EN&ACTION=D&DOC=1&CAT=PROJ&QUERY=012ad3294f00:7529:588e16ff&RCN=92467
132 CEC, op. cit., p. 10.
133 Various (2010) Joint Statement on the launch of the European Wind, Solar, Electricity Grids and Carbon Capture and Storage Industrial Initiatives http://ec.europa.eu/energy/technology/initiatives/doc/2010_joint_statement_initiatives.pdf
134 CEC (2002) Industrial Policy in an Enlarged Europe, COM(2002)690 final, Brussels xx.12.2002.
135 IDEA Consult (2008) Evaluation of the European Technology Platforms (ETPs). Request for Services in the context of the DG BUDG Framework Service Contracts on Evaluation and Evaluation-related Services. Final Report. IDEA Consult, Brussels. ftp://ftp.cordis.europa.eu/pub/technology-platforms/docs/evaluation-etps.pdf
136 IDEA Consult (2008)
137 CEC (2010) Strengthening the role of European Technology Platforms in addressing Europe's Grand Societal Challenges. Report of the ETP Expert Group, October 2009. European Commission, Brussels.

implementing a potential solution should be tackled by concrete proposed actions" in the context of a revised ETP programme.[138]

4.3.2 FINANCING THE SET-PLAN

The Communication putting forward the SET-plan also briefly considered the "mismatch between the sheer magnitude of the energy and climate change challenge and the current levels of research and innovation" and promised a Communication on financing low carbon technologies at the end of 2008. This emerged at the end of 2009 as the Communication *Investing in the Development of Low-Carbon Technologies.*[139] In the Communication the Commission estimates that the EU has to increase from the current €3bn per year to around €8bn per year to effectively move forward the SET-Plan actions, representing an additional investment (public and private) of €50bn over the next 10 years.[140] This includes the cost of research, technological development, demonstration and early market take-up, but *excludes* the cost of deployment and market-based initiatives, such as feed-in tariffs. Interestingly, the Commission promises a Communication in 2010 to specifically address other financing needs, mainly for deployment, to achieve the 20% renewable target in 2020. This does not appear to be in the Commission's work programme for 2010 though. The Commission is careful to underline that the €50bn should be taken as an overall estimate of funding needs, not as a proposal for the future allocation of EU funds, and that future priorities for the EU budget would have to be defined as part of the budget review and in the context of the preparation of the next multi-annual financial framework.[141]

4.4 2006: A BROAD-BASED INNOVATION STRATEGY FOR THE EU

The 2006 innovation strategy entitled "Putting knowledge into practice: A broad-based innovation strategy for the EU"[142] is currently under review. A Communication on a European Plan for Research and Innovation is foreseen for quarter three in the Commission's 2010 work programme.

In September 2006, the Commission proposed a strategy[143] to promote the development of innovative products and services, by supporting knowledge sharing and creating a more 'innovation-friendly' business environment. The innovation strategy proposes ten high priority actions, one of which is of particular relevance here. *Action 9* proposed the d*evelopment of a strategy for innovation friendly 'lead-markets.'* Before we move on to discuss the Lead Markets Initiative we should also mention *Action 2 – the establishment of a European Institute of Technology*, proposed in October 2006.[144] The EIT should contribute to bridging the innovation gap between the EU and major competitors by promoting integration of research, education and innovation. Although not of direct interest to our concerns here, it did include the creation of autonomous Knowledge and Innovation Communities (KICs), joint-ventures of universities, research organisations and businesses. Two of the

[138] CEC (2010) op. cit., p. 45.
[139] CEC (2009) Investing in the Development of Low Carbon Technologies (SET-Plan) COM(2009) 519. Brussels, 7/10/2009.
[140] CEC, op. cit., p. 9.
[141] CEC (2004), op. cit., p. 4.
[142] CEC (2006) Putting knowledge into practice : A broad-based innovation strategy for the EU. COM(2006) 502 final. Brussels, 13.9.2006.
[143] http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/06/325&format=HTML&aged=0&language=EN&guiLanguage=en
[144] COM(2006) 604, http://eur-lex.europa.eu/LexUriServ/site/en/com/2006/com2006_0604en01.pdf; IA: http://ec.europa.eu/education/policies/educ/eit/doc/impact_en.pdf; IA summary: http://ec.europa.eu/education/policies/educ/eit/doc/sec_en.pdf

three KICs designated concerned climate change, the Climate-KIC (mitigation and adaptation) and the KIC-InnoEnergy (sustainable energy).

4.4.1 THE LEAD MARKET INITIATIVE

The Lead Market Initiative is important in the present context because it was hailed at the time as the first comprehensive effort at EU level for a co-ordinated demand-side innovation policy approach. Lead markets were designated in six areas: bio-based products, eHealth, sustainable construction, protective textiles, recycling, and renewable energy. It is clear that the renewable energy and the sustainable construction initiatives would be of most direct relevance here. The Lead Markets Initiative grew out of the 2006 Aho report[145] which concluded that a lack of innovation-friendly markets in Europe holds Europe back as an innovation location.[146]

The Commission defines a lead market as "the market of a product or service in a given geographical area, where the diffusion process of an internationally successful innovation (technological or non-technological) first took off and is sustained and expanded through a wide range of different services."[147] The purpose of the Lead Markets Initiative was to identify a first set of markets with potential to become 'lead markets' and to catalyse co-ordinated action through ambitious action plans for these markets "in order to rapidly bring visible advantage for Europe's economy and consumers." At a more practical level, the Lead Markets Initiative was intended to provide a coherent action package of mostly EU-level and mostly short-term public intervention measures (public procurement, standardisation, legislation, complementary support) in six sectors to facilitate demand growth for innovative goods and services. This was expected to require cooperation in policy coordination and policy implementation at EU and national levels and involvement with industry and other stakeholders such as NGOs and consumer groups.[148] Action plans for each of the six lead markets were adopted in 2007.

The Lead Markets Initiative website shows activities by lead market and by type of instrument (standardisation, labelling, certification; legislation; public procurement; and 'complementary action'). Table 1 gives an overview of what has or is being done in relation to the two lead markets of most interest to us. It is clear that this is either what we might call facilitative action, or action that comes under other initiatives as well. [149]

Table 1 Lead Market Initiative

		LEAD MARKET	
POLICY INSTRUMETNT		**Sustainable Construction**	**Renewable Energy**
	Standardisation, labelling, certification	2nd Generation Eurocodes	Minimum energy performance standards
	Legislation	Screening of national building regulations	Mandatory national targets

[145] The Aho group Report (January 2006) « Creating an Innovative Europe », http://ec.europa.eu/invest-in-research/action/2006_ahogroup_en.htm
[146] CEC (2009) Lead Market Initiative for Europe. Mid-term progress report. Brussels, 9.9.2009. SEC (2009) 1198, p. 8
[147] Commission Communication, Implementing the Community Lisbon Programme: A Policy Framework to Strengthen EU Manufacturing - towards a more integrated approach for Industrial Policy
[148] CEC (2009) Lead Market Initiative for Europe. Mid-term progress report. Brussels, 9.9.2009. SEC (2009) 1198, p.9
[149] http://ec.europa.eu/enterprise/policies/innovation/policy/lead-market-initiative/

	Public procurement	Network contracting authorities	Improve knowledge on demand barriers
	Complementary action	Upgrading skills of construction workers	Overview of all programmes and funds

The Lead Markets Initiative was reviewed in 2009. The review concluded that the Lead Market Initiative is in an early stage of implementation and that policy makers and stakeholders are still engaged in a learning curve in the implementation and governance of this demand-side innovation policy approach. It goes on to say that while in the short term, the activities of the Lead Market Initiative can stimulate demand-side measures in Member States real impacts can only be expected 5-10 years from now. [150]

In addition to observations about the Lead Market Initiative in particular, the mid-term review also makes some interesting observation about "future developments in designing demand-side innovation policy."[151] In particular the review notes that more could be done to make both "the blades and scissors" of supply and demand work better together to stimulate innovation, suggesting that stimulating innovation in markets is often best achieved through 'smart' combinations of supply and demand policy measures. The authors suggest that at Community level, a better co-ordination between the measures under the LMI and supply-side instruments such as the Recovery Plan, the European Technology Platforms, Joint Technology Initiatives and ERANets has a great potential. They note that this approach has recently been proposed in ICT.[152] The relevance of this to low carbon innovation could be explored. With a nod to OECD work on demand-side innovation, the authors also suggest that there is scope to enhance mutual learning between practitioners in and outside the EU in designing demand side innovation policies. In this context they refer particularly to promoting standards to drive innovation, legislation that fosters innovation and new applications of public procurement such as pre-commercial public procurement. The review mentions specifically the RES Directive, SCP/SIP and the Waste Framework Directive as examples of legislation that drive innovation.

4.4.2 2009: REVIEWING COMMUNITY INNOVATION IN A CHANGING WORLD[153]

The Commission published a communication reviewing EU innovation policy in September 2009. This is quite interesting for the general criticisms it makes of Community level innovation policy and also for the way it pulls out a number of low carbon innovation relevant initiatives as examples of EU innovation policy. It is also interesting because it gives an insight into the complexity of the governance structure of EU innovation policy. Finally it is interesting for the language it employs and the perspective on innovation that this reveals.

The Communication begins by defining innovation as "the ability to take new ideas and translate them into commercial outcomes by using new processes, products or services in a way that is better and faster than the competition.'[154] It then goes on to very firmly positioning innovation as a social

[150] CEC (2009) Lead Market Initiative for Europe. Mid-term progress report. Brussels, 9.9.2009. SEC (2009) 1198 , p.4.
[151] P.5.
[152] To cut across the phases of research, testing, procurement and deployment of innovative products and services, as has already been proposed for ICT-based innovations, see COM(2009)116: "A strategy for ICT R&D and Innovation in Europe: Raising the game"
[153] CEC (2009) Reviewing Community innovation policy in a changing world. Brussels, 2.9.2009. COM (2009) 442 final.
[154] P. 3 Citing 'Creating a National Innovation Framework', Science Progress, Richard Nedis & Ethan Byler, April 2009.

achievement citing a range of actors involved, but nevertheless emphasising the importance of the innovation framework. It cites innovation as the precondition for the creation of a knowledge based, low carbon economy. It emphasises that innovation enables European industries to position themselves at the upper end of the global value chain, making Europe the world market leader in energy and resource efficient products and technologies. It suggests that while progress has been made following the re-launch of the 2000 Lisbon Partnership for growth and jobs in 2005, because new competitors are emerging and the challenges getting bigger, the EU must not only sustain the recent positive trend, but further improve it. The purpose of the review was to identify remaining gaps and propose policy orientations to fill them.[155] The Communication highlighted a series of initiatives that have been taken falling into the broad categories of 'improving framework conditions', 'helping to trigger more and quicker market uptake of innovative products and services', 'building synergies' and 'stepping up financial support for research and innovation.' It then went on to outline the lessons that have been learnt so far and the challenges that now have to be mastered.

What is of course of most interest to us are the actions dedicated to improving the market uptake of innovative products and services as well as the actions on financial support. It is interesting that relation to improving market uptake, most of the examples relate to low carbon innovation. It is also of interest that the role of regulation and standardisation "as powerful tools to provide the right incentives and stimulate markets for innovative products and services"[156] is specifically referenced as is the potential for using existing EU public procurement rules to support innovation.

New rules on car emissions is positioned as a way of triggering substantial innovations in the European automotive industry, resulting in cleaner, affordable European cars, and helping to keep the industry globally competitive. Of course there has been significant discussion about whether those rules are sufficiently stringent. The Emission Trading Scheme (ETS) Directive is also mentioned as an initiative that will "foster innovation in renewable energy production and encourage the construction of more environmentally friendly power plants, including new carbon capture and storage (CCS) technologies."[157] The importance of the SET-Plan in achieving the "20-20-20" objectives by 2020 by accelerating the development of low-carbon technologies is referenced as is the 2008 Action Plan on Sustainable Consumption and Production and Sustainable Industrial Policy. The Communication also refers to the revised Eco-Design Directive as a way of providing a legal basis for promoting the market introduction of more environmentally friendly products both in terms of energy efficiency and resource efficiency in situations where "industry fails to set itself sufficiently ambitious targets." Such action can also include using incentives, public procurement and product labelling to ensure that demand underpins minimum performance standards.

In terms of financing the communication refers to the 7th FP which is to early in the chain of innovation to concern us here. It also mentions the Competitive and Innovation Framework Programme which we return to below. The remaining two examples is spending under the Cohesion Policy where some 25% of the 2007-2013 budget is dedicated to innovation financing. This is up from 11% in 2000-2006. Overall some €86bn has been earmarked to support research and innovation. Based on DG Regio's website some of the €8.5bn that goes on 'entrepreneurship' could potentially

[155] P. 3.
[156] P.5
[157] P.5.

be directed at entrepreneurs with low carbon business solutions.[158] However as this is decentralised spending a detailed analysis of this would require additional effort. The other example is from the EU rural development policy from which some €337m is provide to support the development of new products, processes and technologies in the agricultural, food and forestry sectors. Again this is also decentralised spending, and so difficult to find out how much of this might be of potential relevance here. Within the CIP framework some €225m is available for the 2007-2013 period dedicated to SME's and innovation. A specific amount has been set aside for the take-up of environmental technologies, in particular through the co-investment in risk capital funds that provide equity for firms investing in eco-innovation. Such venture capital instruments are intended to help SMEs to gain access to innovation finance.

The review goes on to outline "lessons to be learnt and challenges to be mastered."[159] In particular it addresses the removal of 'critical bottlenecks in the framework conditions for entrepreneurs' and 'enhancing the governance of the EU innovation system.' In terms of bottlenecks it observes that "the EU innovation system continues to suffer from shortcomings that negatively influence the market rewards and incentives for private investment in innovation which as a consequence remains lower than that of our main competitors." This, it is suggested could be remedied by completing the single market; improving the legal framework for the protection of intellectual property; addressing the fragmentation of the venture capital market and stimulating the level of equity funding low; synchronising the standardisation process better with research results and market needs; strengthening the knowledge triangle between business, education and research needs; and increasing the capacity of the EU educational systems to contribute to an "innovative and agile knowledge society."

Given the interest enhancing the availability of capital for early stage financing, the observations about the European venture capital sector are interesting. The Commission suggests that progress towards improving the international competitiveness and performance of the European venture capital sector has been slow, and that there are structural deficiencies in the European early-stage finance market. This includes the absence of private investors, fragmentation of the market and low returns.

While these observations are not directly addressing the provision of financing for low carbon innovation, it nevertheless sketches out an important part of the context which affect *any* innovation, including low carbon innovation.[160]

Finally, the Commission observes that there is a need to improve the governance of innovation. In particular that while there is no lack of innovation support programmes in the EU in terms of numbers. The problem is identified as one of lack of critical mass and coherence. The Commission highlights that innovation support involves seven different Commission services, various agencies and 20 committees with representatives from Member States. It also cites a recent consultation on innovation policy to the effect that users of the available funding find it complex to access.

4.5 2006: ACTION PLAN FOR ENERGY EFFICIENCY: REALISING THE POTENTIAL[161]

[158] http://ec.europa.eu/regional_policy/themes/research/index_en.htm
[159] P.7 onwards.
[160] The recent report by the UK's Green Investment Bank Commission, *Unlocking investment to deliver Britain's low carbon future* (GIBC June 2010) provides a useful outline of different types of financing and the stages of the innovation cycle the intervene in.

The 2006 Action Plan for Energy Efficiency contains much that is of relevance in the context of the development and deployment of low carbon innovation.

The Action Plan set out a framework of policies and measures intended to help realise a 20% savings potential in EU annual primary energy consumption by 2020. It listed a range of cost-effective measures, proposing 10 priority actions to be initiated immediately, and others to be initiated gradually over the plan's six year duration. The plan anticipated that further action would be needed to reach the full potential by 2020. The plan contained some 58 separate actions, many of them with additional sub-actions under them. The actions were grouped into six headings shown in

[161] CEC (2006) Action Plan for Energy Efficiency : Realising the Potential. COM (2006) 545 final. Brussels, 19.10.2006.

Table 2 below.

Table 2 EEAP main headings and priority actions

EEAP heading	P.A. no.	Priority action
Dynamic energy performance requirements for products, buildings and services	1.	Appliance and equipment labelling and minimum performance standards
	2.	Building performance requirements and very low energy buildings ("passive houses")
Improving energy transformation	3.	Making power generation and distribution more efficient
Moving on transport	4.	Achieving fuel efficiency of cars
Financing energy efficiency, economic incentives and energy pricing	5.	Facilitating appropriate financing of energy efficiency investments for small and medium enterprises and Energy Service Companies
	6.	Spurring energy efficiency in the new Member States
	7.	A coherent use of taxation
Changing energy behaviour	8.	Raising energy efficiency awareness
	9.	Energy efficiency in built-up areas
International partnerships	10.	Foster energy efficiency worldwide

The first seven actions are of most interest to us here. The first four actions involved a mix of mandatory and voluntary standards covering both supply and demand side energy. In this context it is of central importance whether targets are sufficiently stringent. The next three involved the issue of financing and incentive structures. A new EEAP is expected towards the end of 2010 or early 2011. Part of what is being debated in this context is the extent to which there should be binding targets on Member States in a parallel way to the targets in relation to renewable energy use.

4.6 2006: COMPETITIVENESS AND INNOVATION FRAMEWORK PROGRAMME[162]

The Competitiveness and Innovation Framework Programme (CIP)[163] was proposed in April 2005 and adopted in October 2006[164] and aims to bring together specific EU support programmes and relevant parts of other programmes related to boosting European productivity, innovation capacity and sustainable growth, whilst simultaneously addressing complementary environmental concerns. The CIP, which covers the period January 2007 - December 2013, constitutes the legal basis for Community actions enhancing competitiveness and innovation, complementing FP7. The CIP makes explicit reference to ETAP, and two of its sub-programmes, namely *Entrepreneurship and Innovation* and *Intelligent Energy,* have the potential to foster the development of environmental technologies.

[162] The discussion of the CIP and the SME Policy for Growth and Employment is taken from previous work by IEEP, in). Pallemaerts, M., ten Brink, P., Herodes, M., Bassi, S., Geeraerts, K. (2007) Study on the potential contribution of the federal authrorities to the development of an integrated policy in the field of eco-innovation in Belgium. An IEEP Report for the Belgian Federal Public Service for Public Health, Food Chain Safety and Environment. Cahier des charges n° AI/JRD/03/06.

[163] Proposal for a Decision of the European Parliament and of the Council establishing a Competitiveness and Innovation Framework Programme (2007-2013) (COM(2005) 121 final)

[164] Decision No 1639/2006/EC of the European Parliament and the Council of 24 October 2006

Eco-innovation is described as a transversal theme of the whole programme, and within one of the sub-programmes, a specific portion of the budget is specially allocated to support eco-innovation.

The CIP has four objectives:

- to foster the competitiveness of enterprises, in particular SMEs;
- to promote innovation - including eco-innovation;
- to accelerate the development of a competitive, innovative and inclusive Information Society; and
- to promote energy efficiency and new and renewable energy sources in all sectors - including transport.

Moreover, the CIP is composed of specific sub-programmes: the *Entrepreneurship and Innovation Programme; the ICT Policy Support Programme;* and *the Intelligent Energy- Europe Programme.* The implementation of the CIP will be outlined in Annual work programmes to be adopted by the Commission each year.

The first and third sub-programmes appear particularly related to environmental technologies; therefore they will be discussed in more detail.

4.6.1 ENTREPRENEURSHIP AND INNOVATION PROGRAMME

This programme is meant to bring together activities on entrepreneurship, SMEs, industrial competitiveness and innovation, including eco-innovation and ETAP. Actions related to eco-innovation[165] may include:

- supporting the take-up of environmental technologies and eco-innovative activities;
- co-investment in risk capital funds providing equity to companies investing in eco-innovation;
- fostering eco-innovation networks and clusters and public-private partnership in eco-innovation, developing innovative business services and facilitating or promoting eco-innovation;
- promoting new and integrated approaches to eco-innovation in, *inter alia*, environmental management and environmentally friendly design of products, processes and services.

Under this programme, the following types of activities are, *inter alia*, eligible for financial support:

- The use of financial instruments for SMEs: High grow and Innovative SME Facility (GIF) and SME Guarantee (SMEG) Facility; Capacity Building Scheme (CBS)
- Services for business and innovation, in particular for SMEs, such as information, feedback, business cooperation and internationalisation services; services for innovation and transfer of technology and knowledge; services encouraging the participation of SMEs in FP7. Business support networks' partners will be selected through calls for proposals.
- Innovation and eco-innovation pilot and market replication projects.
- Policy analyses, development, coordination and twinning, such as studies, data collection, surveys and publications; twinning and meetings of experts, including experts from public institutions; awareness raising and networking; benchmarking of national/regional performances and work on good practices.

[165] As listed in article 14 of Decision No 1639/2006/EC

4.6.2 INTELLIGENT ENERGY - EUROPE PROGRAMME (IEE)

The objective of this programme, which is the continuation of an earlier financial instrument adopted within the framework of EU energy policy in 2002, is to support energy efficiency, the rational use of energy resources, renewable energy sources and energy diversification – including in the transport sector. Its operational objectives are to identify market opportunities for more renewable energy; to increase the uptake of new technologies for intelligent energy use and to identify how to turn EU policy on energy efficiency and renewables into action. The implementation of the IEE is led by the Intelligent Energy Executive Agency (IEEA) and carried out by numerous European projects, events, and around 40 local/regional energy agencies. The programme is structured in three specific fields, each proposing a subset of actions:

SAVE programme, promoting energy efficiency and rational use of resources by:

- improving energy efficiency and the rational use of energy, in particular in the building and industry sectors;
- supporting the preparation of legislative measures and their application.

ALTENER programme, encouraging new and renewable resources by:

- supporting the diversification of energy sources by promoting new and renewable energy sources;
- integrating new and renewable energy sources into the local environment and the energy systems;
- supporting the preparation of legislative measures and their application.

STEER programme, improving energy in the transport sector by:

- supporting initiatives relating to energy aspects of transport and the diversification of fuels;
- promoting renewable fuels and energy efficiency in transport;
- supporting the preparation of legislative measures and their application.

Further horizontal initiatives may include:

- the integration of energy efficiency and renewable energy sources in several economic sectors;
- the combination of various instruments, tools and actors within the same action or project.

Under this programme, the following types of activities shall, inter alia, be eligible for financial support:

- strategic studies for the preparation/review of legislative measures in the field of energy
- the creation, enlargement or reorganisation of structures and instruments for sustainable energy development (local/regional management, financial products etc)
- the promotion of sustainable energy systems and equipment
- the development of information and education

4.7 2005: MODERN SME POLICY FOR GROWTH AND EMPLOYMENT

The SME Policy for growth and employment[166] aims to provide a framework for the various enterprise policy instruments in the EU, in line with the objectives of the Lisbon Agenda. It is a policy document which examines how the Lisbon objectives apply to SMEs and can be implemented in a way which is beneficial to them. It is not a new instrument, but a policy framework for the coordination and improvement of a number of existing and planned instruments. It highlights major challenges for SMEs, proposes new actions to strengthen their capacity to sustain in the market, stimulate growth and create jobs – across all sectors. It also encourages dialogue and consultation with SMEs stakeholders.

The Communication contains a few references to eco-innovation which indicate that this form of innovation is also considered to be of strategic value within the framework of SME policy. The measures proposed for 'improving SMEs access to markets' share some objectives with ETAP. This includes further efforts in relation to the greening of public procurement strategies, which can potentially be beneficial for SMEs.

While addressing the issue of 'improving SME's growth potential', the Commission points out that innovation is essential for the sustainable development of enterprises. The EU is committed to strengthening the innovation and research capacity of SMEs and increasing the volume of technology transfer to them. Among other initiatives, the Commission intends to support innovation in SMEs while improving their environmental performance, within the context of an Environmental Compliance Assistance Programme which is to be launched under the 6EAP.

The main Community instruments through which support for innovation in SMEs is to be provided are the CIP and FP7. The Commission emphasises the need to simplify rules and procedures to promote the participation by SMEs in FP7, but it is questionable whether that objective has truly been achieved. The threshold for access to FP7 funding remains very high for SMEs. It will equally be important to ensure that no obstacles to SME participation are created in the implementing measures of the CIP and that these measures truly reflect the stated priority to be given to eco-innovation and maximise potential synergies with ETAP. Through their participation in the relevant committees, Member States have an opportunity to influence these measures.

4.8 2004: THE ENVIRONMENTAL TECHNOLOGY ACTION PLAN

The overall aim of the 2004 Environmental Technologies Action Plan (ETAP) is to harness the full potential of environmental technologies to reduce pressures on natural resources, improve the quality of life of European citizens and stimulate economic growth. [167] As such it was intended as an important means to implement the 2001 EU Sustainable Development Strategy and to pursue the 2000 Lisbon Strategy.[168] The aim of the Lisbon Strategy was to make the EU "the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with

[166] Commission Communication, *Implementing the community Lisbon programme - Modern SME policy for growth and employment*, COM(2005) 551; http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2005:0551:FIN:EN:PDF

[167] CEC (2004) Stimulating Technologies for Sustainable Development: An Environmental Technologies Action Plan for the European Union. COM(2004) 38 final. Brussels, 28.1.2004, p. 3.

[168] CEC (2004), op. cit., p. 3.

more and better jobs and greater social cohesion,"[169] while, the EU SDS had called for a more integrated approach to policy making in which economic, social and environmental objectives can be achieved at the same time.[170] ETAP has three objectives:

1. To remove the obstacles so as to tap the full potential of environmental technologies for protecting the environment while contributing to competitiveness and economic growth;
2. To ensure that over the coming years the EU takes a leading role in developing and applying environmental technologies;
3. To mobilise all stakeholders in support of these objectives.[171]

ETAP contains 25 actions, including 11 priority actions, grouped around three main areas. These are set out in Table 3 below.

Table 3 ETAP main areas of activity, and priority actions

Main Area of Activity	**P.A. no.**	**Priority Action**
Getting from research to market: (5 actions including 3 PAs).	1.	Increase and focus research, demonstration and dissemination
	2.	Establishing technology platforms
	3.	Establishing European networks of technology testing, performance verification and standardisation
Improving market conditions: (18 actions including 7 PAs).	4.	Develop and agree on performance targets for key products, processes and services
	5.	Mobilising financial instruments to share the risks of investing in environmental technologies
	6.	Review state aid guidelines
	7.	Review environmentally harmful subsidies
	8.	Encourage procurement of environmental technologies
	9.	Raise business and consumer awareness
	10.	Provision of targeted training
Acting globally: (2 actions including 1 PA).	11.	Promoting responsible investment in and use of environmental technologies in developing countries and countries in economic transition

It also contains 3 supporting actions: the regular review of the action plan (every two years), the establishment of a European Panel on Environmental Technologies and the open method of coordination. Measures proposed were to be implemented at the Community level, by Member

[169] CEC (2004), op. cit., p. 2.
[170] CEC (2004), op. cit., p. 2.
[171] CEC (2004), op. cit., p. 3.

States' national and regional authorities, research organisations and business/industries. ETAP does not set any budget or target for progress to be made within these priority areas.[172] Below we outline the priority actions which are of most relevance here.

Getting from research to markets

The actions contained in getting from research to markets, are mainly focussed on the earlier parts of the innovation chain. Notably ETPs.

Improving market conditions

This group of actions was intended to address the problem of central concern here: "that many potentially significant environmental technologies exist, but are underused."[173] Citing factors such as the lock-in or existing technologies, price signals that favour less eco-efficient solutions, difficult to access finance and low consumer purchaser awareness, the Action Plan includes a set of measures aimed at encouraging the market uptake of environmental technologies. These are based on providing positive incentives, an appropriate regulatory framework, public procurement and voluntary instruments. Seven of the eleven priority actions were in this category. The first five are of particular relevance here.

Priority Action 4: Develop and agree on performance targets for key products, processes and services.

Performance targets have the potential to stimulate both the development of and take-up of products, processes and services with a lower environmental impact. If they are dynamic, i.e. reviewed and recalibrated regularly, they can induce a process of continual improvement. In this action, the Commission undertook to work with Member States and other relevant stakeholders to consider how best to develop a process to identify performance targets for environmental technologies. The means of achieving this was the IPP, the eco-design of EuP, voluntary agreements, policy initiatives and more generally regulation.[174]

Priority Action 5: Mobilising financial instruments to share the risks of investing in environmental technologies.

This action was dedicated to increasing the risk capital available to companies developing environmental technologies. It contained measures that were dedicated both to existing Member States and to, what was then the acceding countries, in view of what the Commission notes as the particularly low levels of risk capital available there. In this action, the Commission undertook to explore a range of potential opportunities for mobilising financial instruments with the EIB, the EBRD, Member States and relevant stakeholders. The means of achieving this action was diverse (European Technology start up facility; SME guarantee facility, ETS Financial Facility; JI/CDM technical assistance facility; JREC venture capital; EIB contribution to EU Growth initiative; EIB Innovation 2010 initiative).[175]

Priority Action 6: Review State Aid Guidelines

The purpose of environmental state aid is to incentivise companies to a higher level of environmental protection than would have been the case without the aid. It is thus a mechanism which can potentially stimulate demand for technologies with a lower environmental impact. The control of

[172] Pallemaerts *et al.* (2007, p.39
[173] CEC (2004), op. cit., p. 13.
[174] CEC (2004), op. cit., p. 41.
[175] CEC (2004), op. cit., p. 21.

state aid for environmental protection at the Community level is intended to guarantee that aid measures will lead to higher levels of environmental protection than would have been reached in the absence of aid. The positive effects of aid must outweigh the negative effects in terms of distortions of competition, taking account of the polluter pays principle.[176] The Commission noted, in the Communication setting out the ETAP, that recent experience with the guidelines for environmental state aid suggested that the framework was not properly adapted to the increasing sophistication of investments in environmental technologies, nor to new forms of public/private partnerships.[177] In this action the Commission therefore undertook to review the guidelines for environmental state aid with Member States. A new version of the Guidelines for Environmental State Aid was adopted in 2008, replacing the earlier 2001 Guidelines. State aid for environmental protection is also one of the instruments for the implementation of the energy action plan for the period 2007-2009 aimed at establishing an integrated European energy and climate policy.[178] In the new guidelines, a 10% bonus aid may be granted "where an investment improving on Community Standards or improving the level of environmental protection in the absence of standards involves eco-innovation."[179] In addition recent revisions to the regulations covering the so-called "block exemptions" which give automatic approval a range of state aid. This has enlarged the number of areas where state aid can automatically be given without notifying the Commission. A number of these concern measures relating to innovation in general. Here we only highlight the ones that are specifically relevant to the low carbon innovation agenda:

- investment to go beyond Community standards for environmental protection;
- acquisition of transport vehicles which go beyond Community environmental protection standards;
- early adaptation to future environmental standards for SMEs;
- investment in energy saving measures;
- investment in high efficiency cogeneration;
- investment in the promotion of energy from renewable energy; the environment, in the form of tax reductions.[180]

Priority Action 7: Review Environmentally Harmful Subsidies

Under this action the Commission undertook to use a framework developed by the OECD to identify the most significant subsidies that have a negative impact of the environment. The action was to be undertaken together with Member States and regional governments. A study was also launched in support of this action, undertaken by IEEP.[181] ETAP foresees that subsequent to the review, each level of government should take the appropriate action, as quickly as possible, to remove or reduce the negative effects of such environmentally harmful subsidies, for example by introducing new taxes or tax incentives combined with harmonised performance targets.[182] This is an area which could be of great significance for the deployment of low carbon innovations. But it is also likely to prove

[176] http://europa.eu/legislation_summaries/competition/state_aid/ev0003_en.htm
[177] CEC (2004), op. cit., p. 17.
[178] http://europa.eu/legislation_summaries/competition/state_aid/ev0003_en.htm
[179] http://ec.europa.eu/environment/etap/policy/priority_en.html#003
[180] http://europa.eu/rapid/pressReleasesAction.do?reference=IP/08/1110&format=HTML&aged=0&language=EN&guiLanguage=en
[181] Ref – in fact I think there were two studies…. One around 2005 and one around 2009.
[182] CEC (2004), op. cit., p. 18.

politically difficult. This action was also intended to complement a broader Communication on the use of market-based instruments in environmental protection to update the 1997 Communication on taxes and charges and widen its scope to issues such as tradable permits. This was eventually published in 2007 as the Green Paper on Market Based Instruments for Environment and Related Policy Purposes.[183]

Priority Action 8: Encourage procurement of environmental technologies

The ETAP noted that public procurement accounts for around 16% of the EU's GDP, or some €1,450 billion.[184] It is thus generally accepted as a powerful demand side driver. It also noted that the Commission had already contributed to this area by proposing what was to become the 2007 Directive on Energy End-use Efficiency and Energy Services. In order to stimulate demand, the Directive required Member States to ensure that the public sector plays an exemplary role.[185] It also noted the development in the context of IPP, several initiatives (a handbook for public procurers, a product-group data base and voluntary action plans for public procurement) designed to encourage procurers to make use of the many possibilities in existing public procurement directives.[186] The Action Plan looked forward to investigate the setting of performance based requirements in public procurement procedures, as a way of pulling environmental technologies into the market. Sometimes known as technology procurement, buyers or groups of buyers, formulate technical specifications that challenge companies to go beyond the current best available technologies. The Action Plan also states that life-cycle costing needs to be promoted for long-term investments such as buildings and energy supply systems.

ETAP has been reviewed three times since 2004, in 2005[187], 2007[188] and 2009.[189] Two reviews have been conducted of the national roadmaps requested in the first implementation report. The most recent evaluation, conducted by Ecorys, evaluated ETAP over the period 2004-2009. It mainly focussed on the 11 priority actions as this was the areas where there had been most activity, and also the areas where sufficient and sufficiently conclusive evidence could be found.[190] In relation to the first goal of the ETAP, Ecorys concluded that conditions for the development of environmental technologies in the EU have improved as a result of a number of co-ordinated activities such as increased attention on developers and on the market. Ecorys caution however that, several barriers, mainly of an administrative and financial nature, still hamper the full exploitation of the opportunities offered by ETAP. Echoing the 2009 review of the EU's innovation policy, Ecorys suggests that progress should be made through enhanced co-ordination of existing programs and instruments at local level, rather than the implementation of new measures. They also observe that in terms of opening markets to eco-innovations, action through the legislative framework is preferable to soft action. In relation to the second goal, Ecorys did not consider that there was

[183] CEC (2007) Green Paper on Market Based Instruments for Environment and Related Policy Purposes. COM(2007) 140 final. Brussels, 28.3.2007.
[184] Based on GDP in 2002. In CEC (2004), op. cit., p. 18.
[185] Ref Art. 5(1).
[186] CEC (2004), op. cit., p. 19.
[187] CEC (2005) Report on the implementation of the Environmental Technologies Action Plan in 2004. COM (2005) 16 final. Brussels, 27.1.2005.
[188] CEC (2007) Report of the Environmental Technologies Action Plan (2005-2006); COM(2007) 167 final. Brussels, 2.5.2007.
[189] Ecorys (2009) The implementation of the Environmental Technologies Action Plan. Draft Final Report. Under the Framework Contract ENV.G.1/FRA/2006/0073. 23 August 2009. Ecorys Research and Consulting. P. 27-28.
[190] Ecorys (2009) The implementation of the Environmental Technologies Action Plan. Draft Final Report. Under the Framework Contract ENV.G.1/FRA/2006/0073. 23 August 2009. Ecorys Research and Consulting. P. 27-28.

sufficient information available and also that the situation would in any case be very industry specific. However, in policy terms, Ecorys did consider the EU a leader, specifically compared to the US, although this position could be challenged if the declarations of the Obama Presidency are matched by actions. Finally, in relation to the third goal of the ETAP, Ecorys concluded that since 2004, stakeholder networks in relation to environmental technologies have increased and that much of this is due to ETAP. However, attention will need to be paid to ensure long-term effects and constancy over the coming years.

The Commission is currently exploring the possibility of moving to a strengthened eco-innovation policy as a follow up to ETAP.[191] This would be more broad-based expanding the focus on green technologies in ETAP to encompass all aspects of eco-innovation.[192] A study has been launched to support DG Environment in the impact assessment of an Eco-innovation Action Plan.[193] A non-paper "Innovation for a Sustainable Future: From the Environmental Technologies Action Plan to the EU Eco-Innovation Action Plan" serves as the basis for the study.[194] According to the CEMA website[195], consultations based on the draft were foreseen for May 2010.

5 TOWARDS AN ASSESMENT OF THE EU POLICY LANDSCAPE

In the above we have set out some of the most important features in the EU policy landscape for the development and deployment of innovations for a low carbon economy. We have paid particular attention to measures that are relevant to the deployment of low carbon innovations. A number of observations can now be made with respect to the various features of the policy landscape we have outlined as well as in regard to the overall picture that emerges from an examination of the parts.

5.1 OBSERVATIONS REGARDING KEY FEATURES OF THE POLICY LANDSCAPE

First of all, as an expression of the direction of travel for the EU over the next ten years, what does ***Europe 2020*** tell us about the shape of things to come in terms of the most important aspects of the policy landscape for the development and deployment of low carbon innovations? Overall it tells us that economic growth is paramount and that innovation is attributed a strategic role in achieving this. Within this, low carbon innovation specifically is also given an important role, both as part of the intention to decouple growth and resource consumption and as a source of growth in its own right, safeguarding and capitalising on what is perceived to be the EU's first mover status in this area.

[191] Technopolis Group and Wuppertal Institute (2010) Support for the IA of a possible Eco-innovation Action Plan. Draft 'Progress report' by Technopolis Group and Wuppertal Institute under Framework Contract B5/ENTR/2008/006-FC-LOT5. Version 1.0 26 April 2010. The draft progress report published on the CEMA website, states that it intended to stimulate discussion and that it should not be referred to. the CEMA website. http://www.cema-agri.org/docs/556.pdf

[192] ETAP (2010) From ETAP to an Eco-innovation Action Plan. ETAP Newsletter Issue 18, April 2010. http://ec.europa.eu/environment/etap/published_files/07042010_newsletter_etap_issue_18.pdf

[193] The draft progress report puts forward and analyses four policy options: 1) Continuation of the present ETAP: focussing on environmental technologies, and with specific interventions that are (mainly) on facilitating interaction between supply and demand of knowledge; 2) No EU action: no ETAP. 3) New Eco-innovation Action Plan: the focus of EcoAP is similar to that of ETAP: mobilising the public and private sector and stakeholder actions. The three main areas will be retained but the specific options would change to address barriers to eco-innovation more broadly; 4) Ambitious EU eco-innovation policy: characterised by a maximum use of fiscal incentives, regulation and policy integration to achieve a systemic eco-innovation of the EU economy.

[194] Technopolis Group and Wuppertal Institute (2010), op. cit., p. 5.

[195] The first draft of the report is available from the CEMA website. http://www.cema-agri.org/docs/556.pdf

Innovation Union, Resource Efficient Europe, and Industrial Policy for the Globalisation Era are the Europe 2020 flagships of greatest significance in the present context. While they contain much of potential interest, there is a certain overlap between them, and with existing measures, such that it is often difficult to determine what is new and additional to existing policy initiatives.

The ***Innovation Union Flagship*** suggests that climate change, energy and resource efficiency is one of the areas around which the Commission is proposing to re-focus R&D and innovation policy. The scope is in principle the whole innovation chain. EU level action will centre on improving the framework conditions including improving access to capital and making full use of demand side policy such as public procurement and smart regulation. This is encouraging as access to capital in the early stages of commercialisation can be difficult to obtain. Moreover, depending on what precisely is meant by 'smart regulation' in the context of the Innovation Union flagship this could, if it means initiatives such as the Japanese top runner approach, clearly be helpful in creating markets for low carbon innovations. Of potential note is also the reference to strengthening and developing the role of EU (funding) instruments in support of innovation.

There is clearly a link to be made here with the debate about 'climate proofing'[196] the budget in general, and the work now underway to define the post-2013 multiannual framework in particular. This is something which could be explored further: what scope should there be for addressing the deployment of low carbon innovations in the post-2013 multiannual framework, and what would be the options for arranging this? What scope would there be for using carbon markets as a source of finance?

While some funding is available on innovation in general, the 2009 review of the innovation strategy highlighted a perception among stakeholders that it can be difficult to access funding, consequently the Commission also promises to work to streamline administrative procedures to facilitate access to funding. This general condition would of course also affect entrepreneurs who are seeking to commercialise low carbon innovations.

A number of initiatives are outlined in relation to the flagship ***Resource Efficient Europe***, but in most cases it is difficult to determine what is additional to existing plans. Depending on its reception by the other European Institutions, Member States and Stakeholders, the Communication from DG CLIMA putting forward a vision of the structural and technological changes required to move to a low carbon, resource efficient and climate resilient economy by 2050 could be of significance by providing a vision of the trajectory to 2050. This could also be an argument for binding targets on Member States in relation to energy efficiency action, and to be considered by the Commission later in 2011. The nature and ambition of targets (at different levels) and of supporting measures is clearly potentially a key part of the EU policy landscape for the deployment of low carbon innovations, as is the existing Energy Efficiency Action Plan.

It is worth noting that the debate about energy efficiency which has been going on since the late 1970s could be said to be to a very large extent about the deployment of low carbon innovations, whether these be of a technological or a behavioural nature. Therefore it is not really surprising that

[196] Medarova-Bergstrom, K., Volkery, A., Schiellerup, P., Withana, S., Baldock, D. (2011) Strategies and Instruments for Climate Proofing the EU Budget. IEEP, Brussels.

the limitations of this debate, in so far as it has by and large focussed on efficiency as opposed to absolute reductions, are also relevant to the debate about the deployment of low carbon innovations. Like the SCP/SIP Action Plan, the EEAP has the potential to deliver substantial deployment of low carbon innovation on a product by product basis. A general condition for this will be that minimum performance requirements are sufficiently stringent, are updated at appropriate intervals and are accompanied by appropriate supporting measures such as, for example, transparent benchmarking and technology procurement. But importantly, the focus on products does nothing to halt the trend towards *more* energy consuming products, with *greater* functionality, resulting in *increasing use*, and therefore increasing energy consumption. This challenge, we suggest, has not really been taken up in a direct way in the flagship Resource Efficient Europe. Nevertheless, it lies at the heart of the problem.

Moving from the deployment of innovations in relation to individual products to the deployment of (a set of interlinked) innovations in the context of what might be considered as bundles of products, such as buildings, increases complexity. Moreover, it should be noted that while the energy efficiency debate has now to a large extent been re-cast as one about low carbon, but it is important to keep the distinction. This is because a focus on carbon, say in the context of buildings, can lead to sub-optimal solutions.

A related example would be transport. At present the two emerging choices as far as decarbonising the transport sector is concerned are biofuels and electrification. But the sustainability concerns associated with these are by no means solved. Thus, if demand is not brought under control, these are unlikely to be viable solutions, but on the contrary usher in new sustainability challenges.

The ***flagship on Industrial Policy*** does seem to recognise that the transition to a low-carbon economy would require transition management. It is recognised that while the challenges of globalisation and adjusting products and processes to a low carbon economy will create business opportunities for some, other sectors may have to re-invent themselves. Industrial policy is as we have seen (Section 3.4) an area where the Union competence is limited to carrying out 'actions to support, coordinate or supplement' the actions of the Member States (TFEU, Art. 6). Together with the DG CLIMA Communication on a roadmap for a low-carbon economy by 2050 and the DG ENER roadmap for a low carbon energy system by 2050 as well as the Communication on a European plan for research and innovation, the Communication on industrial policy will be setting out the wider strategic context for a transition to a low carbon economy to 2050, and thus the wider context of the policy landscape for the development and deployment of low carbon innovations that we are concerned with here. As noted above, such wider strategic pronouncements can play a role in improving a better investment climate for low carbon innovation as they hold the promise of future markets.

It is clear is that while there are a number of potentially significant policy initiatives in the pipeline, nevertheless, we suggest that there is some considerable cause for concern that the overall level of ambition will not be sufficient to truly succeed in the de-coupling Europe's growth from resource and energy use, thus placing at risk our capacity to secure sufficient reductions in emissions.

We have already made some concluding remarks on the ***SCP/SIP*** (and the EEAP) above. The emphasis of SCP/SIP is on products policy, with some supporting action relating more to production and innovation processes and international action to facilitate the creation of markets internationally. The dynamic policy framework for products is significant in and of itself, and the fact

that it is situated in the context of a wider industrial policy and regulatory context is encouraging, nevertheless it included no concrete targets. As noted, the stringency of targets will be key in securing any meaningful reduction in emissions, and the SCP/SIP does not address the proliferation of products, functionalities, and use.

The ***SET-plan*** is, as the name suggests very much focussed on a set of specific technologies, and little or no attention is given to services, or the need to reconceptualise business strategies in a broader sectoral perspective. A range of initiatives across a diverse set of technologies are set in motion, tailored to the situation of each technology. A distinction is made between technologies in terms of whether they are relevant for the 2020 or the 2050 targets. While the Plan does make reference to the deployment end of the innovation chain, and indeed to the challenge of bridging the "valley of death" between supply and demand, in practice the balance of the Plan seems to be very much on research and development and thus the supply side of the innovation chain. The communication dedicated to the financing of the SET-plan specifically excluded deployment, although another communication specifically addressing this, especially in relation to renewable was promised. The most market 'pull' oriented section of the SET-plan is in the context of international co-operation. In particular "building new market opportunities for EU industry" in developing and emerging economies and a variety of options for "further engaging with such countries" are outlined.[197]

Within the EU innovation strategy, the ***Lead Market Initiative*** expressly seeks to address the demand side of the innovation chain, and the sectors it addresses contains some that are expressly of interest here. However, it is also clear that Lead Market Initiative has some way to go before it may bear fruit, and also, in relation to the sectors of interest to us, it is not clear yet what it is that the Lead Market Initiative brings in addition to what is already there. The 2009 review of the EU's innovation strategy highlights a number of important issues and draws attention to the importance of regulation (and standardisation) in stimulating markets for innovative products and services in general, it is also noteworthy for the way it show cases a number of key regulatory instruments and action plans relating to the resource efficiency agenda as examples of EU level actions dedicated to improving the market uptake of innovative products and services.

SMEs are responsible for half of the EU turnover and represents almost 99% of the all EU companies. For meeting the Lisbon Strategy's objective of making Europe the most competitive and dynamic knowledge-based economy, the EU policy had a particular focus on stimulating the innovation and competitiveness of the SMEs. The ***Competitiveness and Innovation framework Programme*** (CIP) was meant to become the main legal basis grouping all Community actions in the field of (eco-)innovation and competitiveness. Together with FP7, CIP is one of the main instruments for achieving the Lisbon agenda goals and it is likely to remain at the same importance level in supporting the new Europe 2020 strategy. Consisting in three distinct programmes, CIP shares indeed its objective of strengthening Europe's competitiveness and innovative capacities with the FP7, but focuses primarily on innovation as a business process, rather than being limited to technological research. Therefore CIP wants to encourage the usage of renewable energies, information and communications technologies (ICT) and to promote energy efficiency. Moreover, CIP stimulates the SMEs innovation activities and provides better access to finance and business support services by offering grants and a large portfolio of venture capital via the European Investment Bank (EIB) and European Investment

[197] CEC, op. cit., p. 13.

Fund (EIF). The financial instruments address the innovative SMEs needs for debt capital and risk guarantee in incipient business stages of incubation, start-up and early expansion stages.

Measures relating to low carbon innovation is only a sub-set of the various activities going on under ***ETAP***. ETAP brings together a number of existing initiatives and proposes some new ones. A substantial number of initiatives are dedicated to improving market conditions. And several of these are also dedicated more or less exclusively to the demand side of the innovation chain. Nevertheless, the second report on ETAP concluded that "all activities have to be stepped up and carried out on a new scale, with much more emphasis on demand."[198] Moreover, it appears that the main added value of ETAP is in agenda setting and influencing rather than in very concrete measures. It will be interesting to see whether the review of ETAP will lead to a more comprehensive and ambitious approach and how this will relate to the upcoming innovation and industrial strategies.

5.2 OBSERVATIONS REGARDING THE OVERALL PICTURE

A number of observations can now be made about the overall picture which emerges of the EU policy landscape for the deployment of low carbon innovations with reference to the framework developed in Section 3 (summarised in Section 3.5). In this context we can also point to some areas or uncertainty which would benefit from additional exploration and clarification.

Does the ensemble of policies add up to a coherent whole?

The overall picture which is emerging from the analysis is one of an interpenetrating web of strategies, action plans, programmes and more specific measures, rather than a coherent framework. The recent review of Community innovation policy makes a similar point deploring the "lack of critical mass and coherence" in innovation support programmes: "innovation support involves seven different Commission services, various agencies and 20 committees with representatives from Member States."[199] It is clear that the development and deployment of innovations for a low carbon future is at the very least at the confluence of the work of DG Climate Action, DG Enterprise and Industry, DG Research, DG Regional Policy, DG Energy, DG Environment, and DG Competition. Time will tell if the Europe 2020 flagship initiative on innovation will be able to provide a coherent umbrella, and the place that low carbon innovation, and in particular the deployment of such innovations would have.

Are there some elements missing?

As outlined in noted in Section 3.5, this question has multiple dimensions. We can ask what sectors, technologies/end-uses, and actors are addresses, and whether these are the 'right' ones. We can also ask whether intervention addresses the 'right' functions (in the innovation system) and whether this is done in a timely manner in respect of the phase of technological development. Is there a sufficient balance between supply and demand related policies, and do policies allow innovations to traverse the valley of death in security? Is there sufficient attention to innovations that are not technological? In this paper we have provided a relatively high level analysis, providing an overview of the main elements in the EU policy landscape. We suggest that future work could usefully explore one or more of these questions in greater depth.

[198] CEC (2007) Report of the Environmental Technologies Action Plan (2005-2006). COM(2007) 162 final. Brussels, 2.5.2007.
[199] CEC 52009) Reviewing Community innovation policy in a changing world. COM(2009) 442 final. Brussels, 2.9.2009., p.10.

Appendix B gives an overview of the technologies covered by the different policy initiatives referred to in the text. The question of whether these are the right ones goes beyond the scope of the paper here but could, and should, be explored separately. Here we have e.g. raised the question of whether the focus on electric cars and biofuels is appropriate, given that mobility demand is not under control. Beyond that there is of course the issue of whether the investments in CCS and of nuclear energy are the right priorities. These are debates that we will have to have as a society when considering what low carbon innovations should be developed and deployed. It is clear that EU innovation policy is overwhelmingly concerned with technology, and plays relatively little attention to non-technological innovations. This also applies to low carbon innovations. It must be said though, that the Innovation Union flagship, begins to soften this picture a little, at least at the level of intention.

The question of whether EU level public policy intervenes in the right functions of the innovation system and at the right phase of technological development can be taken together here. It is clear that notwithstanding the Lead Market Initiative, the overwhelming emphasis in on supply-side, with much less attention to the formation of markets, or demand side policy. More emphasis appears to be expended on the development of innovations, including low carbon innovations, than on the deployment of innovations. Again, the Innovation Union flagship appears to pay more attention to the demand side.

It might be of interest to develop a more fine grained critical analysis e.g. of funding streams through different EU level funding instruments and to form a view on what can be said about access to financing on the basis of this. We have given a first overview in Appendix A. With this should go an assessment of *who* has the institutional capital to access such funding and any implications that might have. More attention could also be paid to the private sector side of the financing coin, and in particular an exploration of how the structural deficiencies in the European early-stage finance market (e.g. absence of private investors, fragmentation of the market and low returns) referred to in the Commission's review of the EU's innovation strategy, might interact with the deployment of key low carbon innovations.

We also think that it might be useful to develop a more comprehensive analysis of the EU system of innovation which draws more systematically on the work of Hekkert and others working in a similar vein. While we are aware of work that addresses individual national systems, we are not aware of work that undertakes the same analysis in relation to the as a whole EU, and which focuses specifically on low carbon innovations. In this context it would be key to distinguish more explicitly between the different innovation dynamics that apply to different types of low carbon innovation. We have, with Grubb, drawn attention e.g. to the distinction to be made e.g. between product policy and energy systems, and in between we might place the building stock. It would also be helpful to think about how low carbon innovation policy interacts with regional disparities in the Union, and whether there is an opportunity for redressing imbalances.

To a certain extent the answer to the question about whether something is missing from the policy landscape, also depends on where we choose to draw the boundary around low carbon innovation policy. Section 3.2 set out a collection of market and system failures that innovation policy in general and low carbon innovation policy in particular, could address. One of these is the problem of externalities, and chief among these is the lack of a price on carbon. As we have seen, other policy

initiatives have sought to address this in particular the EU-ETS. Also, the presence of (more or less) dynamic- performance targets in a variety of context can be a more or less explicit part of innovation policy. These could be described as demand side policies to the extent that they remove technologies from the market that do not fulfil certain criteria thus creating market opportunities for those remaining. When signalled well ahead of time, they can also provide a signal for where the market will be going in the future, and therefore act as an incentive on business to develop appropriate solutions that meet the future standard. The design, timing, communication, and supporting measures for performance standards are therefore key.

At issue here is the relationship between the strategies, action plans, programmes and instruments outlined above and what could be called the overarching framework of climate policy including the EU-ETS, effort-sharing agreement and EU level measures aimed at the non-traded sectors, and renewable energy directive. This forms part of the context in terms of proving an overall architecture for controlling EU emissions, or even the heart of the matter in so far as EU-ETS is capable of giving an adequate carbon signal and the Community level measures aimed at the non-traded sectors are capable of mobilising a demand pull (and giving investors sufficient confidence about the shape of things to come) and Member State policies implementing the various element at the national level are able to contribute in parallel ways. The question here is, where does low carbon innovation policy end and more general climate and energy policy begin? There will not be a 'hard and fast' boundary as the two policy areas are intimately related.

Is the array of initiatives sufficient in relation to the scale of the problem?

A number of elements are missing from the EU policy landscape for the deployment of low carbon innovation as we have seen in the section above, although there is an issue about where we draw the boundary around the low carbon innovation policy landscape. However, even if we adopt an inclusive definition, the array of policies currently assembled will not get us to where we need to get to by 2050 (i.e. 80-98% reduction).[200] As we have seen there are some generic weaknesses in relation to innovation policy in Europe, and some specific ones in relation to low carbon innovation, and there seems to be limited focus so far on policies specifically focussed on deployment. The picture is less sombre if we look beyond policies that are expressly innovation focussed and concern ourselves with e.g. with the policy framework on energy related product policy, the EU-ETS and the renewable energy Directive. But even so, in particular in relation to the two first, performance targets, or the capacity of the EU-ETS to act as a driver of innovation are unlikely to be sufficient. Although some of the language e.g. in Europe 2020, is beginning to reflect the wider challenges of ecological restructuring that flow from the need to make the transition to a low carbon economy, Europe does not yet have an industrial policy which addresses this sufficiently.

What is the working theory of innovation, low carbon innovation, and the transition to a low carbon economy which emerges from the various policy documents?

The impression we get it that the perspective has evolved over time, and is influenced by which DG is in charge of a given policy initiative. Broadly we would say that a more linear view of innovation is probably giving way to a more complicated systems perspective and that in particular the 'systems of

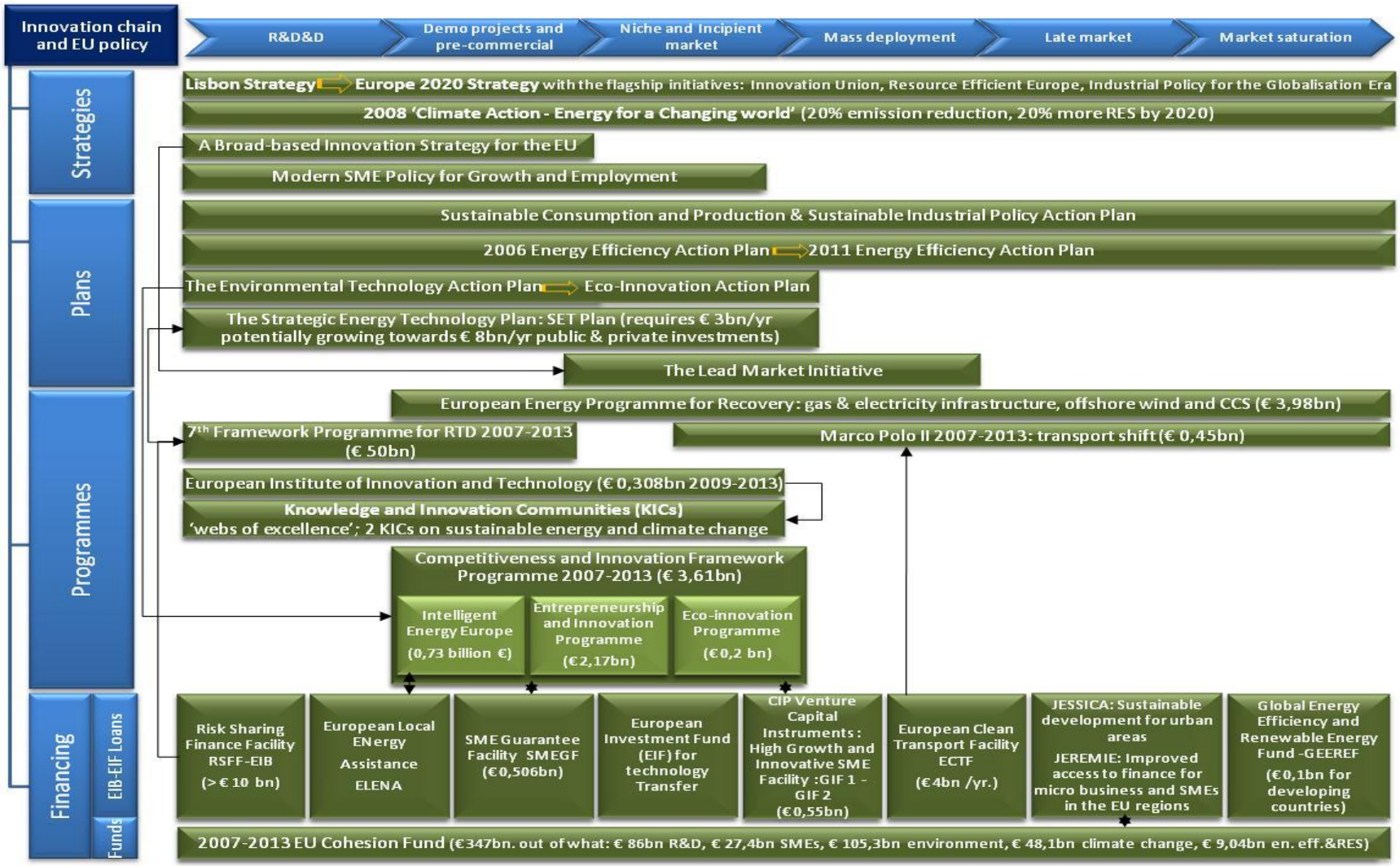
[200] Brussels European Council Presidency Conclusions 29/30 October 2009, p.3.

innovation' perspective appears to be influential. But a more fine-grained analysis would be required to establish these impressions with greater confidence. What is clear, is that the boundary of ambition is usually drawn at efficiency, and so fails to integrate the insights of Jänicke and of the socio-technical systems perspective. We therefore think that the perspective informing the Commission's thinking on innovation should be enriched to take account of the more structural issues raised. There is a need for a more ambitious and more fundamentally transformative approach to innovation in the Community if we are to reach our climate change objectives to 2050.

In this paper we have tried to go to 'the end' of low carbon innovation argument. This comes in part out of spending many years in the context of the debates about energy efficiency, debates which are now to some extent playing out in a greenhouse gas (or carbon) emissions frame. Thus, efficiency is not likely to be enough, and the focus on individual products or indeed sectors is likely to miss the bigger picture. We have drawn on the work of ecological modernisation and in particular Jänicke to illustrate this bigger picture and the need to engage with the wider structural transitions, including the necessary dialogues around that with various partners, if we are to manage to find the key out of our present carbon lock-in.

APPENDICES

APPENDIX A: EU STRATEGIES, PLANS, PROGRAMMES AND FINANCING SOURCES IN RELATION TO THE DIFFERENT STAGES OF THE INNOVATION CHAIN



APPENDIX B: MAIN EU POLICY INITIATIVES AND THE RELATIONSHIP TO THE LOW-CARBON TECHNOLOGIES

	Renewable energy (RES)	Clean coal and CCS technology	Energy efficient technology	SMEs support for innovation and low-carbon technology
Europe 2020 Strategy with the flagship initiatives: Innovation Union, Resource Efficient Europe, Industrial Policy for the Globalisation Era				
2008 'Climate Action - Energy for a Changing world' (20% emission reduction, 20% more RES by 2020, confirms the 20% energy savings voluntary target by 2020)				
A Broad-based Innovation Strategy for the EU				
Modern SME Policy for Growth and Employment				
Sustainable Consumption and Production & Sustainable Industrial Policy Action Plan				
2006 Energy Efficiency Action Plan (and the announced new Energy Efficiency Action Plan)				(mainly in terms of energy services companies)
The Environmental Technology Action Plan (and the announced Eco-Innovation Action Plan)				
The Strategic Energy Technology Plan: SET Plan				
The Lead Market Initiative				
Competitiveness and Innovation Framework Programme				

Legend:

High Medium Low	How much the given policy addresses the particular issue?

APPENDIX C: Low-carbon innovation in selected countries: Denmark, France, Germany, The Netherlands and the United Kingdom

SEE THE SEPARATE DOCUMENT ATTACHED